# L2 & L3 Factorized Corrections for CMSSW_1_5_2

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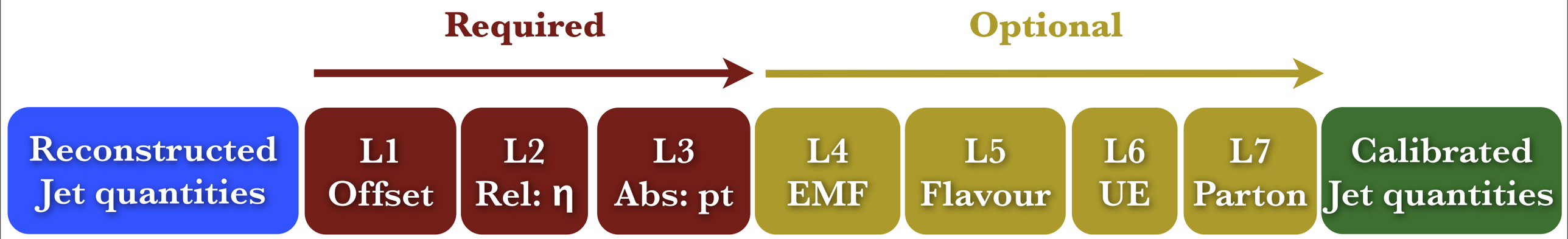
Fermilab

# Outline

- Introduction
- Definitions & technique
- L3 Correction
- L2 Correction
- Corrections at work
- L2 & L3 vs MCJet Corrections
- Example
- Conclusions

# Introduction




## Motivation and goals

**L2 Correction:**

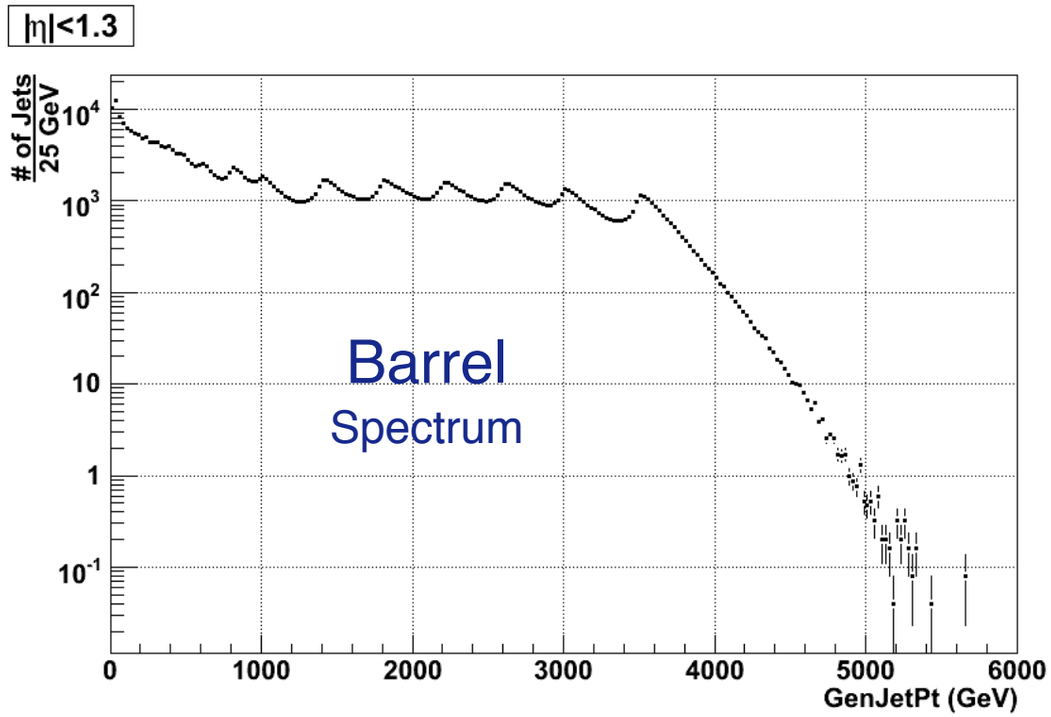
Uniform response in η. When real data will be available it will be determined by Dijet Balance.

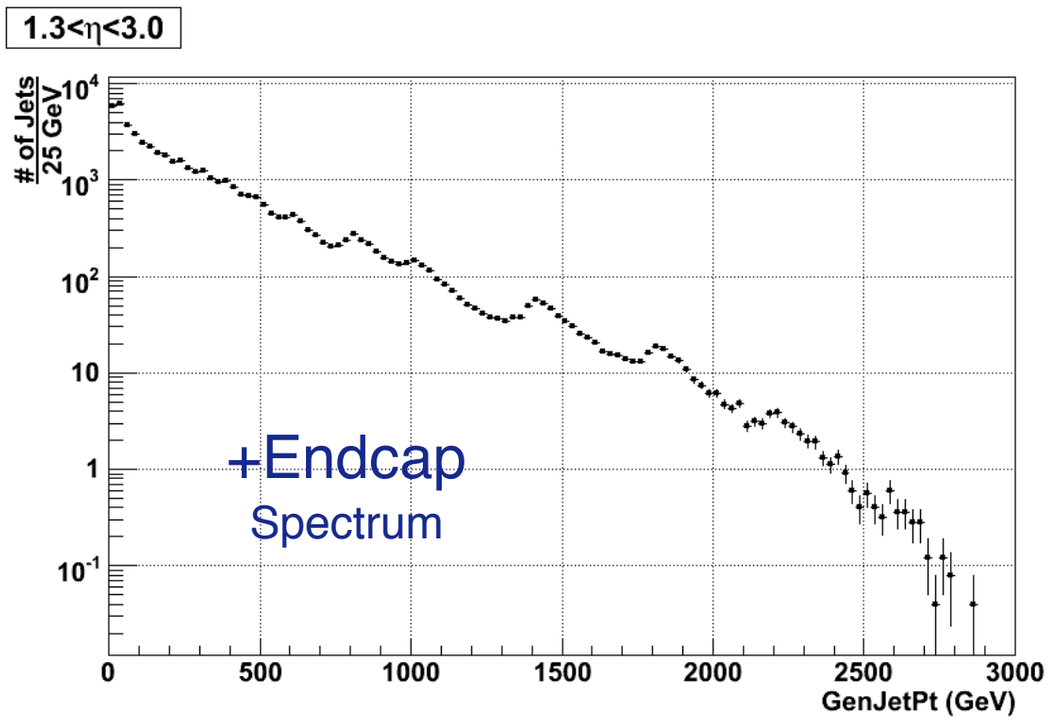
**L3 Correction:**

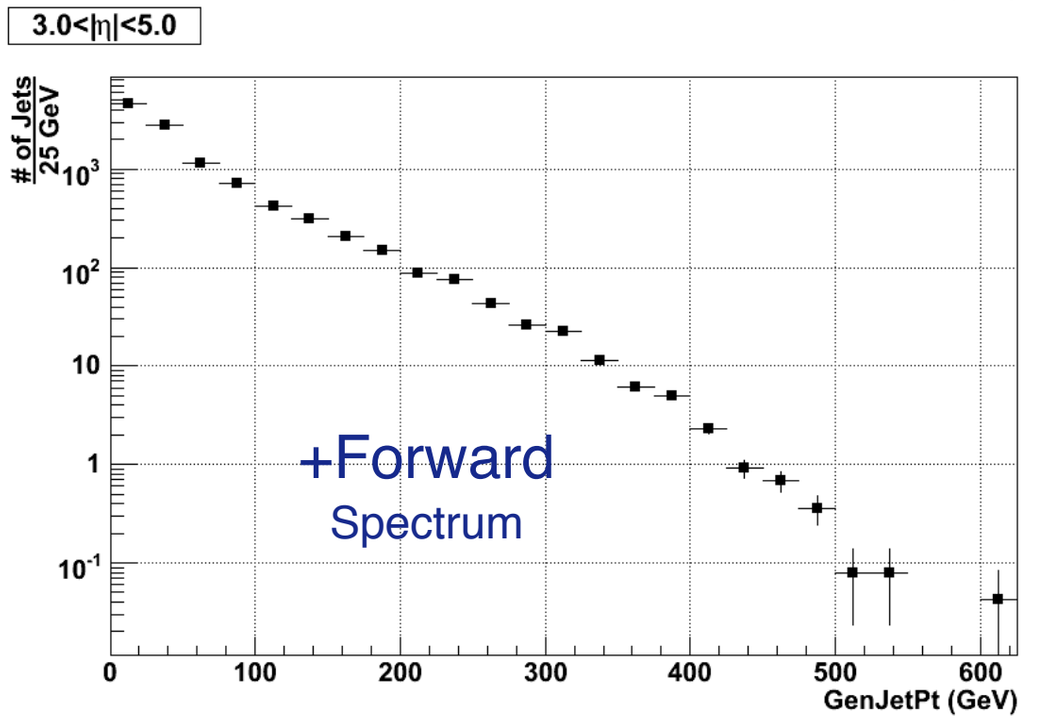
Absolute scale of jet transverse momentum in a control region. When real data will be available it will be determined by γ/Z +jet Balance.

# Data sample

- CSA07 QCD (CMSSW_1_5_2).
- ~ 4M Events.
- All pt_hat bins included.
- No weighting.
- 2 leading GenJets (to get roughly flat unweighted spectrum).
- CaloJets to GenJets matching: R<0.25.
- Min CaloJetPt: 1 GeV.
- Jet algorithm: iterativeCone5



# Definitions

## Fundamentals:

➡ **Although the corrections should be finally applied as a function of the reconstructed quantities, the calculation is based on binning in terms of GenJetPt because this approach is almost insensitive to the spectrum used. For flat spectrum, binning in CaloJetPt gives the same result *(backup I)*.**

➡ **As a measure of jet response was used the difference between the CaloJetPt and GenJetPt, rather than their ratio, due to better mathematical properties and in accordance to the technique used for the L4 corrections.**

➡ **Throughout the presentation η is CaloJet_η.**

## Definitions:

- $\Delta P_T = CaloJetP_T - GenJetP_T$
- $< X >=$ average of the X distribution.
- $<< X >>= \pm 1.5\sigma$ gaussian fit around the peak of the X distribution.
- $Response(< GenJetP_T >) = \frac{<GenJetP_T> + <<\Delta P_T>>}{<GenJetP_T>}$

# L3 technique

➡ **Control region: $|\eta|<1.3$.**

➡ **Measurement of the Response in 27 "fine" GenJetPt bins.**

➡ **Fitting of the response (R) vs GenJetPt with a smooth function:**

$$R(x) = p_0 - \frac{p_1}{[\log(x)]^{p_2} + p_3} + \frac{p_4}{x}$$

➡ **Calculation of the correction (C) vs CaloJetPt by numerical inversion so that the relations:**

- $R(GenJetP_T) \times C(CaloJetP_T) = 1$
- $CaloJetP_T = GenJetP_T \times R(GenJetP_T)$
- $GenJetP_T = CaloJetP_T \times C(CaloJetP_T)$

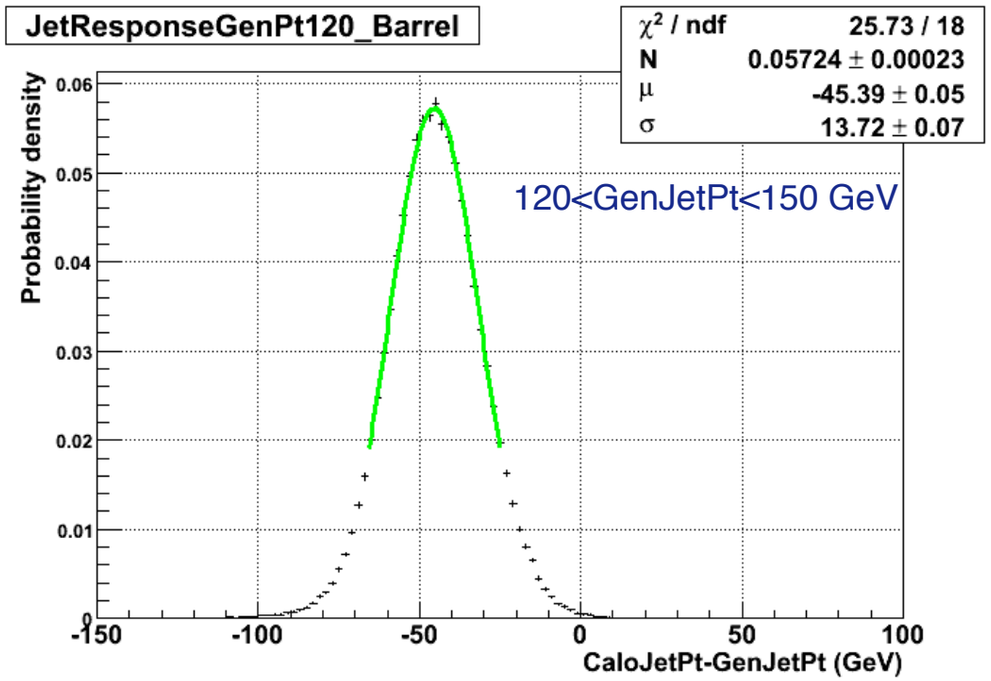
**are satisfied simultaneously by construction.**

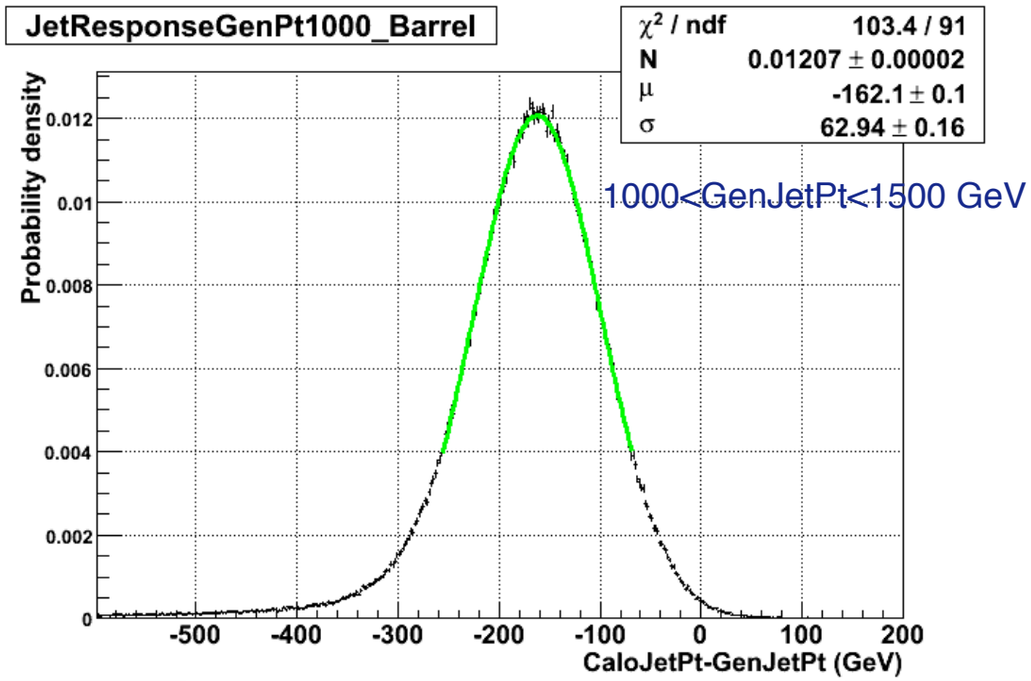
➡ **Although it is possible to measure the correction separately by binning in terms of CaloJetPt, it both fails to satisfy the above relations and is heavily spectrum dependent (*backup I*).**

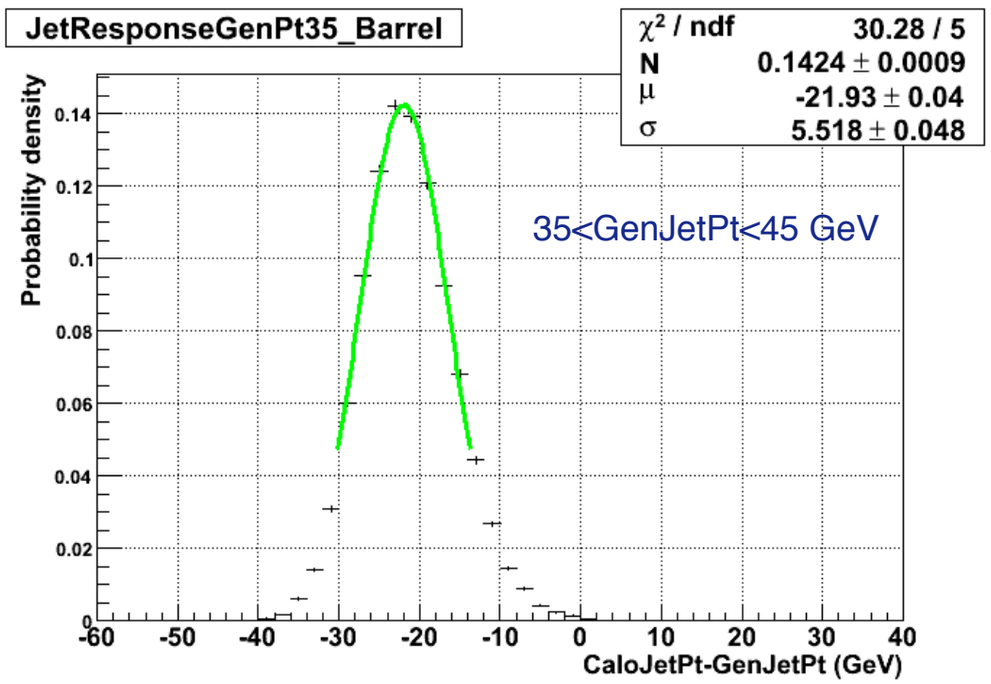
➡ **Fitting of the correction (C) vs CaloJetPt with a smooth function:**

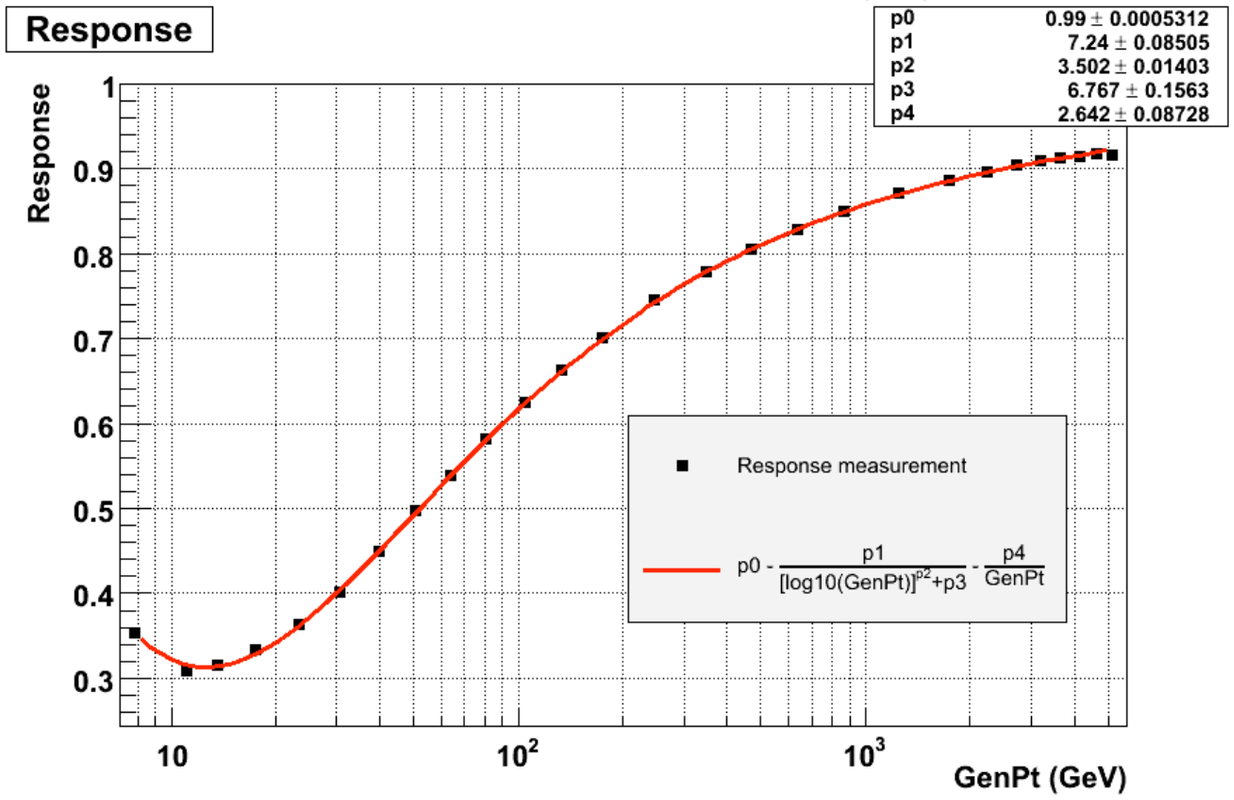
$$C(x) = p_0 + \frac{p_1}{[\log(x)]^{p_2} + p_3}$$

# Response measurement (|η|<1.3)

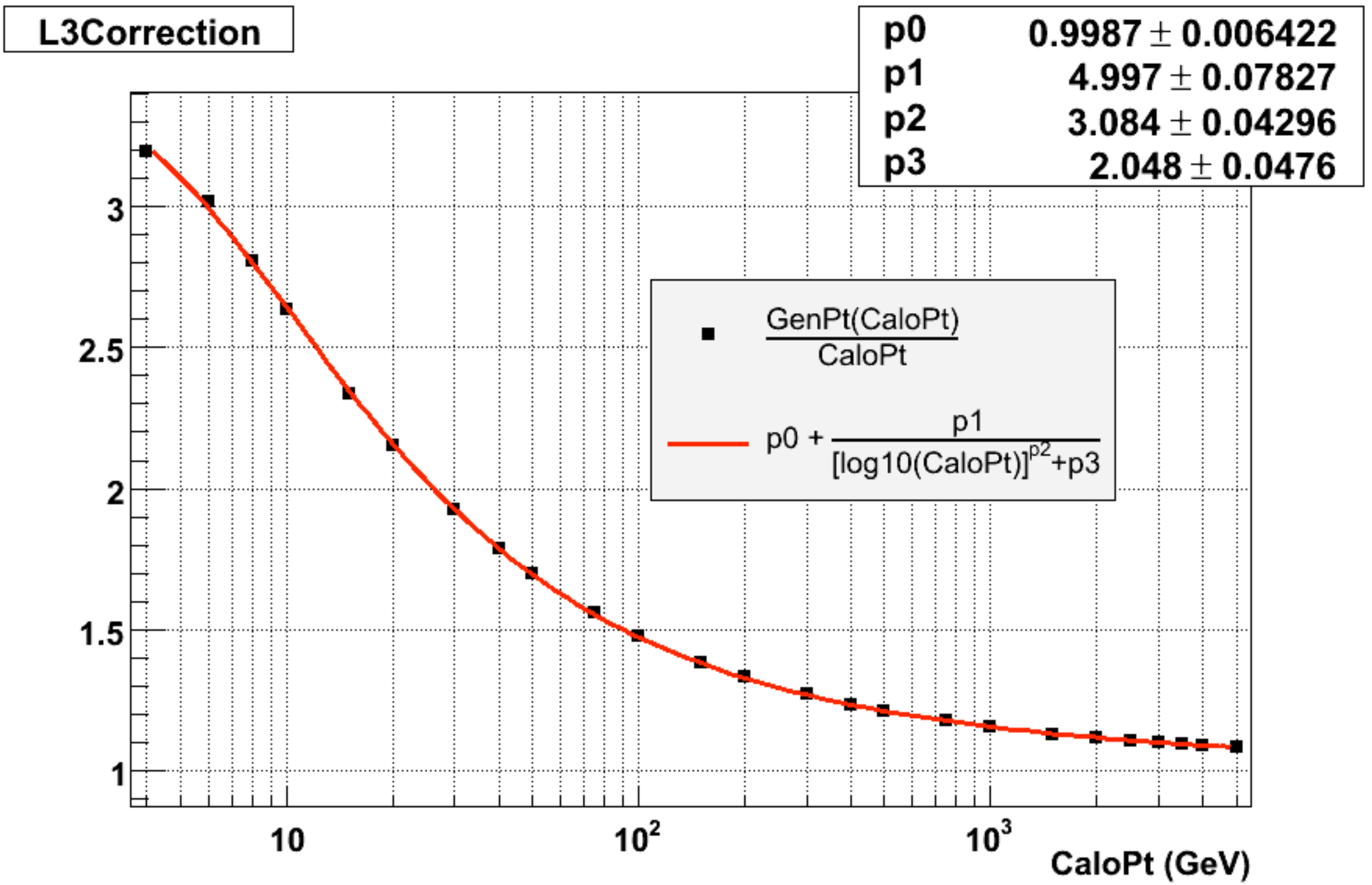


# L3 Correction



# L2 technique

➡ **Measurement of the Response in 27 "fine" GenJetPt bins and 82 η bins, corresponding to the CaloTower boundaries.**

➡ **Fitting of the response (R) vs GenJetPt with a smooth function in each of the η bins:**

$$R_\eta(x) = p_0(\eta) - \frac{p_1(\eta)}{[\log(x)]^{p_2(\eta)} + p_3(\eta)} + \frac{p_4(\eta)}{x}$$

➡ **For a given CaloJetPt(η) numerical inversion of the relation:**

$$CaloJetP_T(\eta) = GenJetP_T \times R_\eta(GenJetP_T)$$

**to get the GenJetPt.**

**It is crucial that the ratio of CaloJetPt's refers to the same GenJetPt. In the data driven method this is naturally achieved by using the dijet system.**

➡ **The L2 Correction is defined as:**

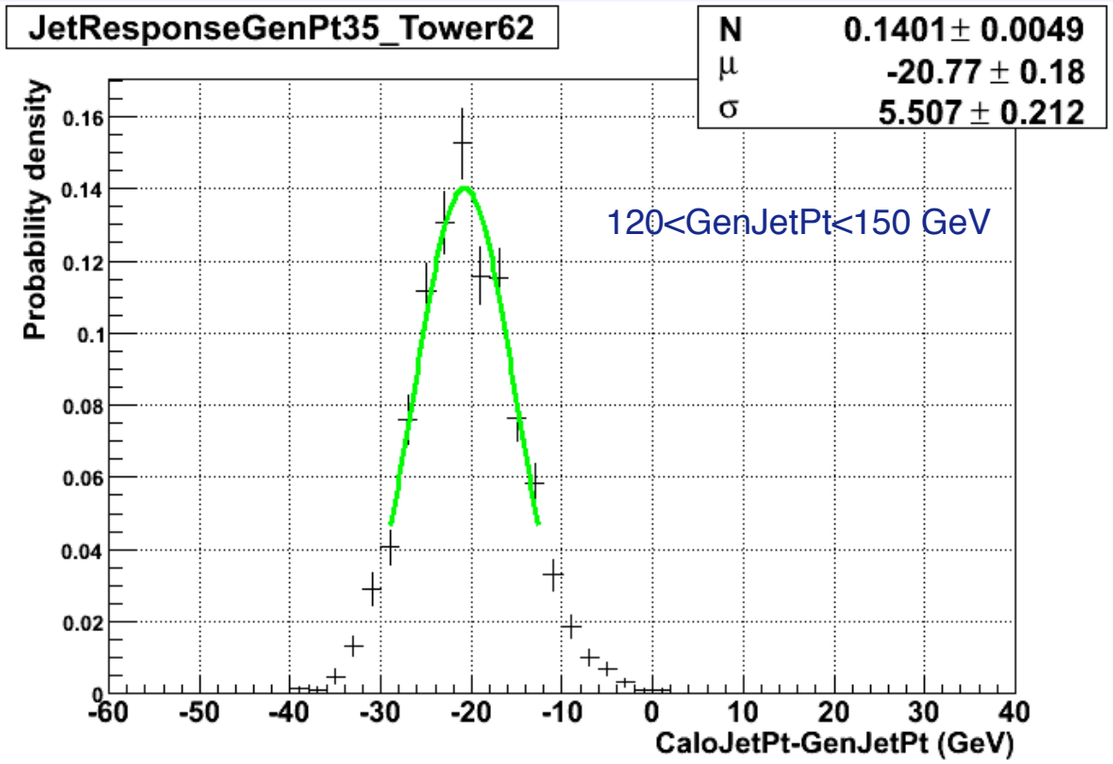
$$C_\eta(CaloJetP_T) = \frac{CaloJetP_T(\|\eta\| < 1.3)}{CaloJetP_T(\eta)} = \frac{GenJetP_T \times R_{|\eta|<1.3}(GenJetP_T)}{CaloJetP_T(\eta)}$$

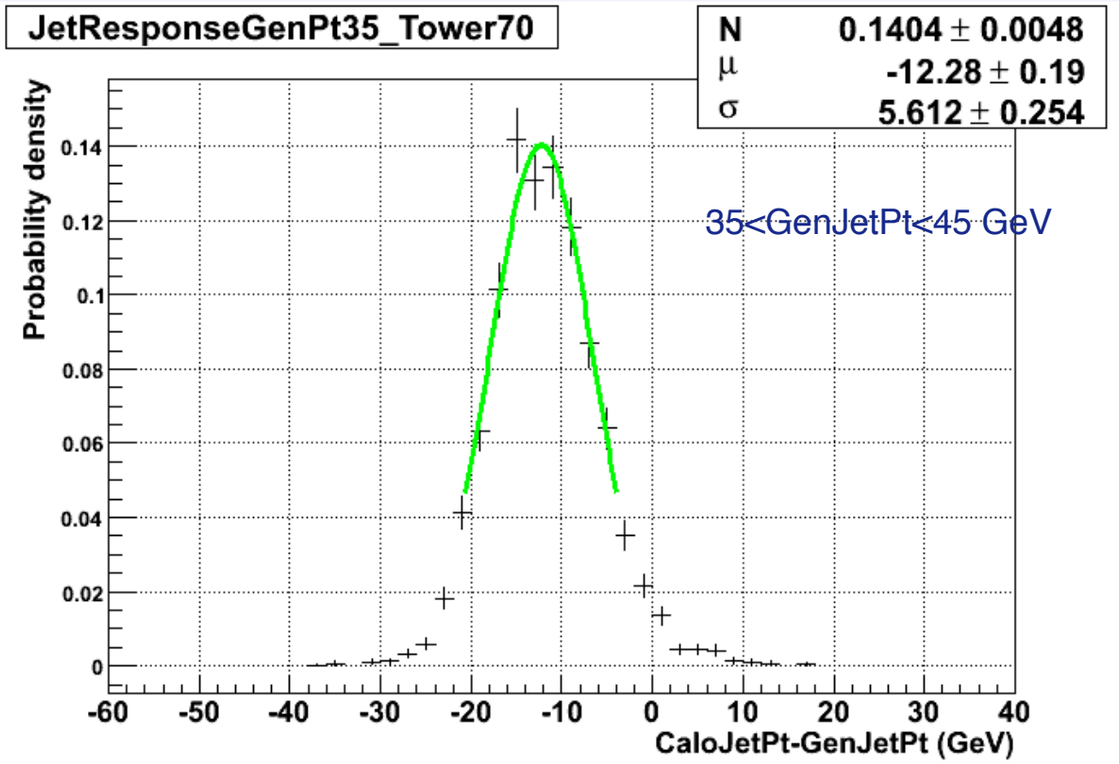
➡ **Fitting of the correction (C) vs CaloJetPt with a smooth function:**

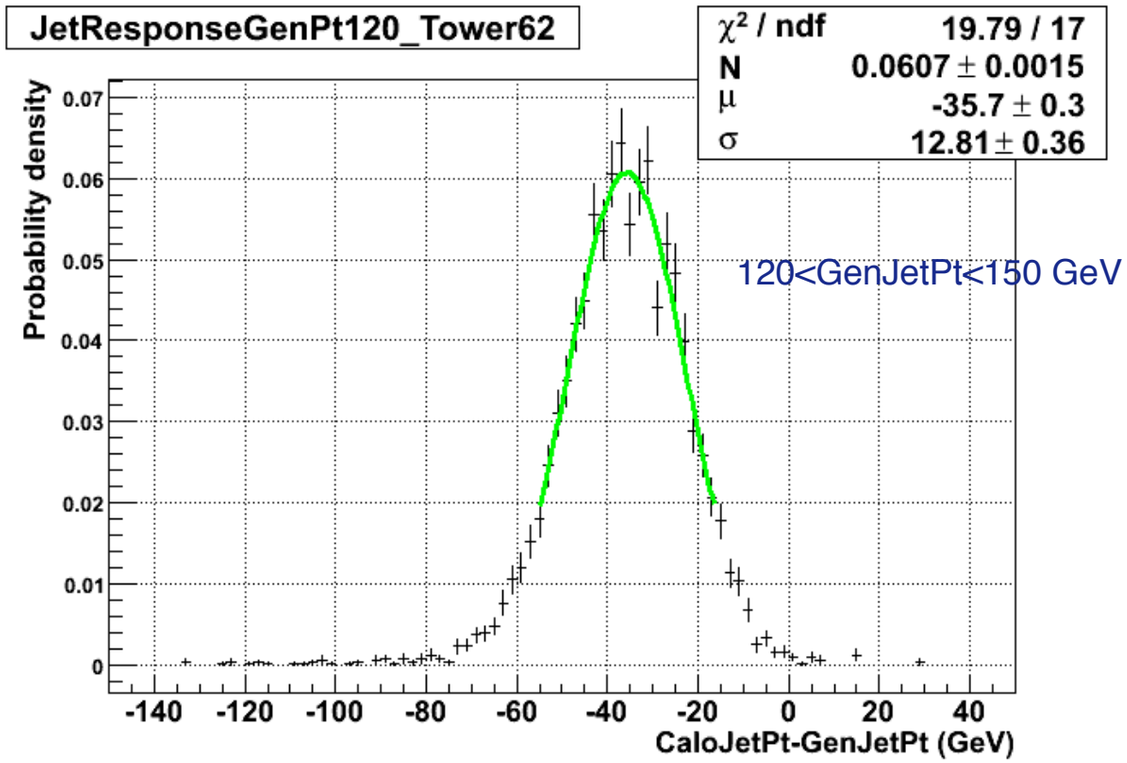
$$C(\eta, x) = \sum_{n=0}^{5} p_n(\eta) \times [\log(x)]^n$$

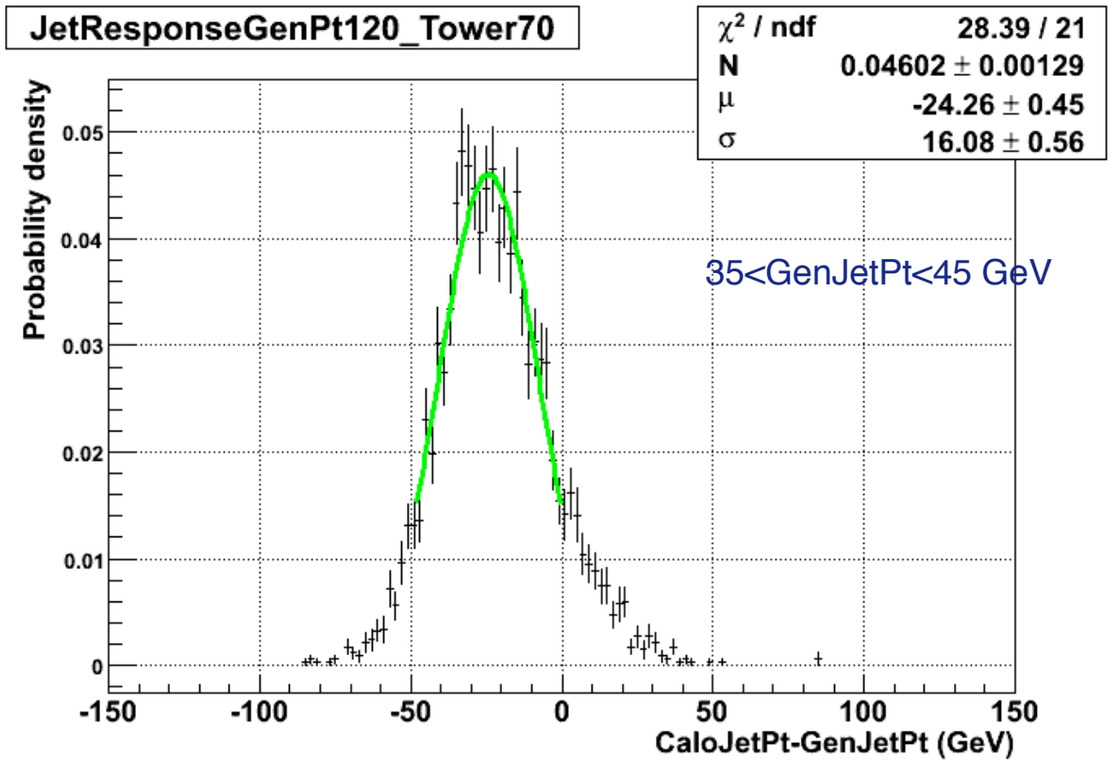
➡ **Quadratic interpolation between neighbouring η bins (to achieve continuity in η).**

# Response measurement in η bins

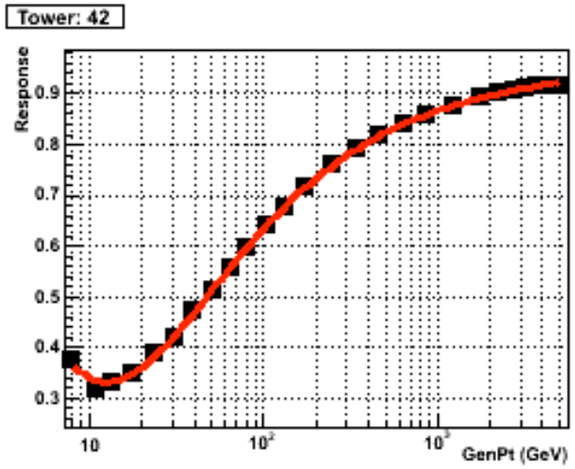


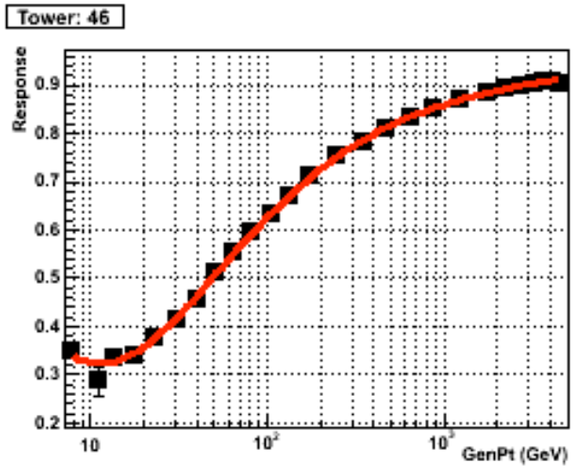



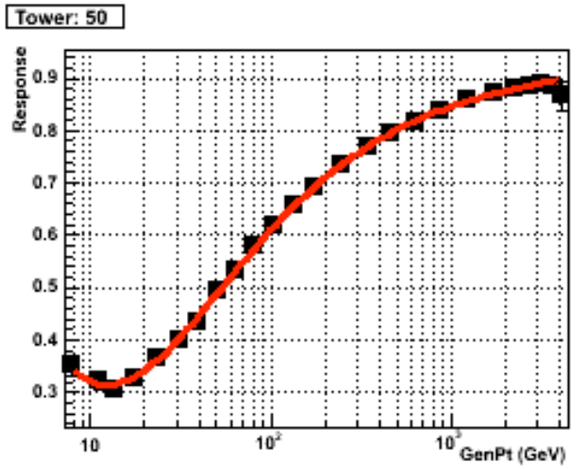



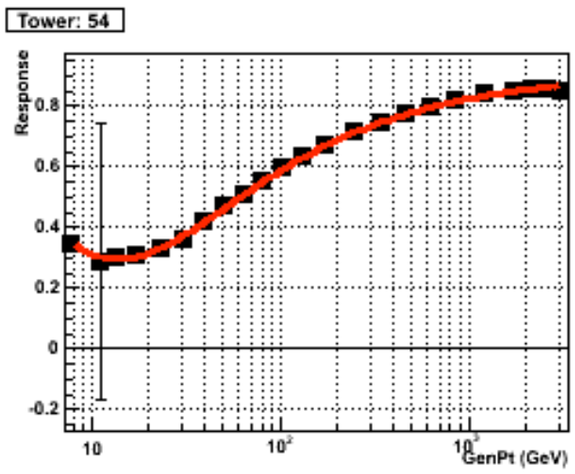



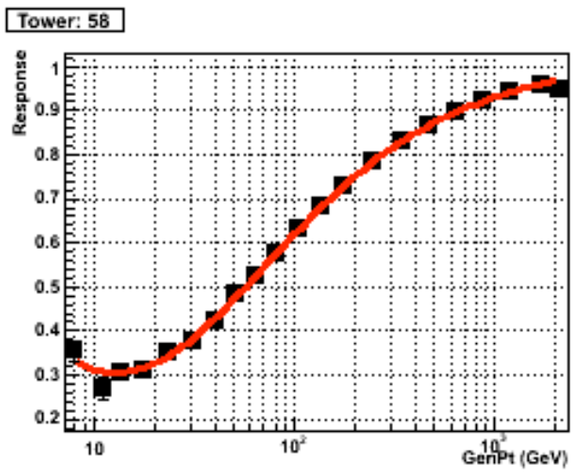
# Response fitting in η bins

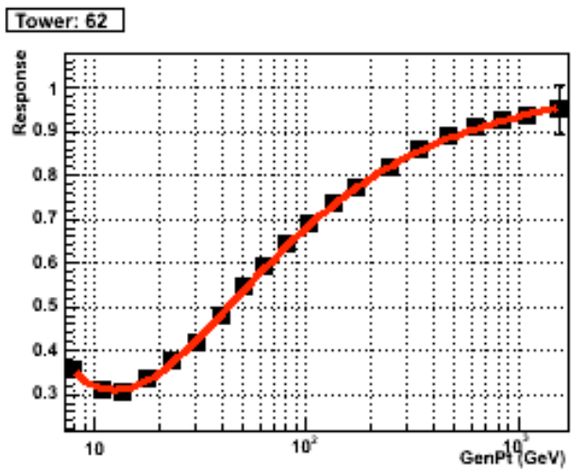


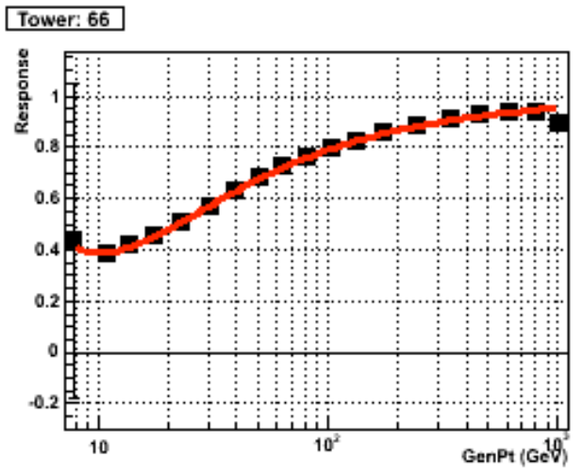



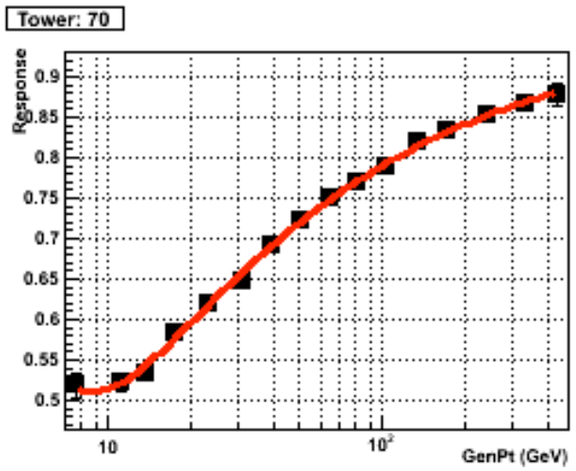



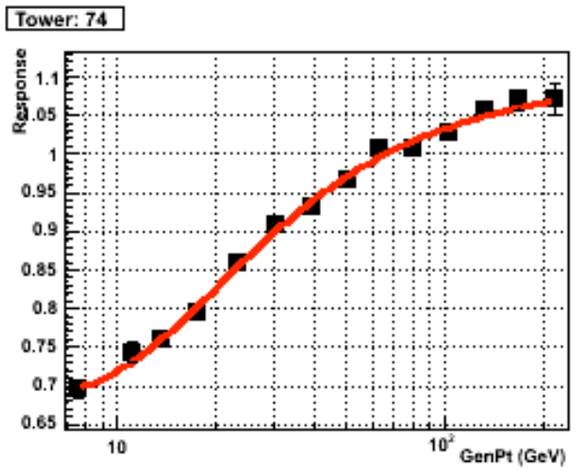



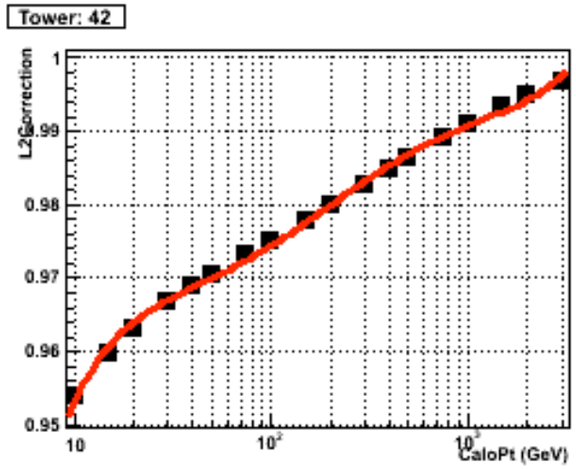



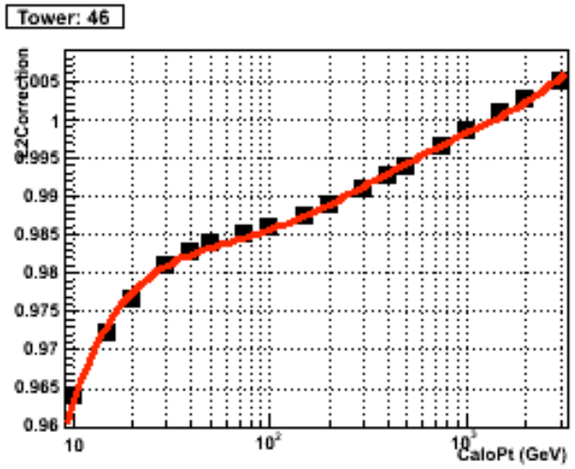



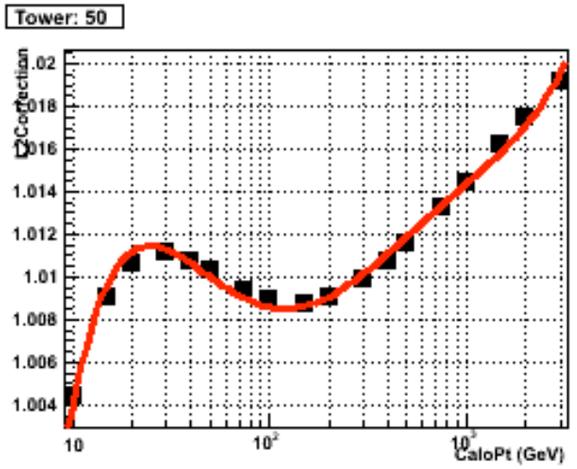



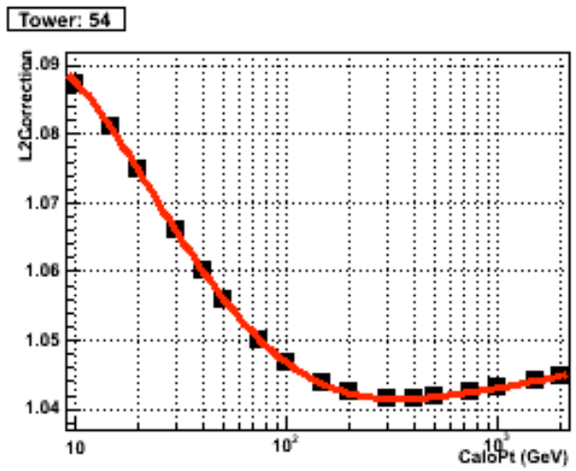



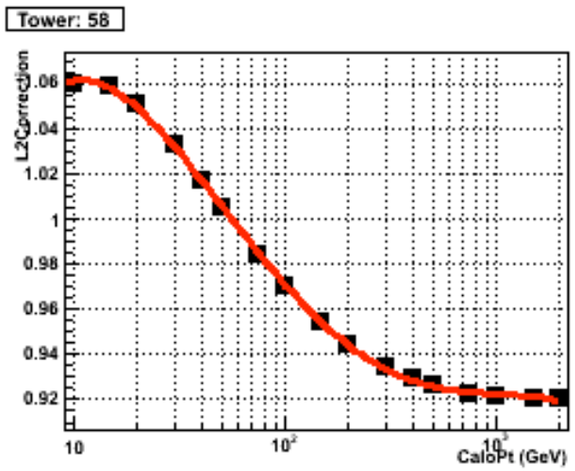
# L2 Correction fitting

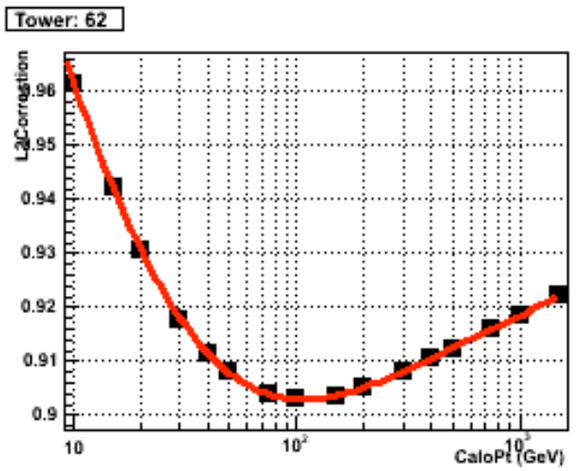


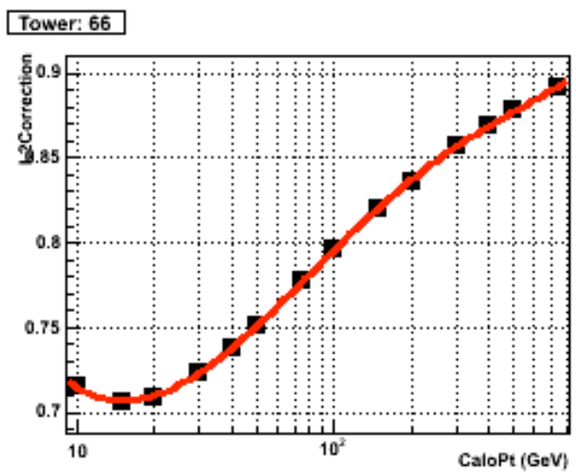



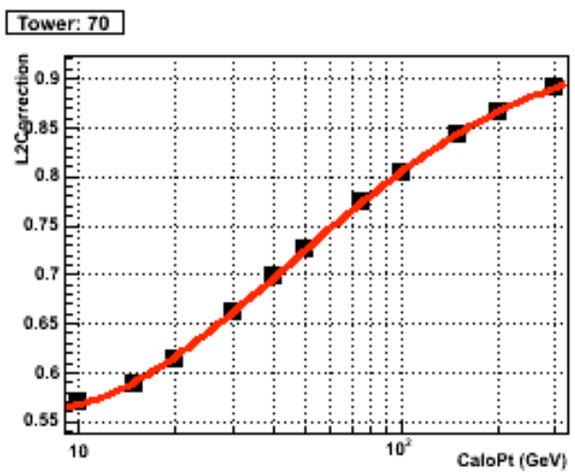



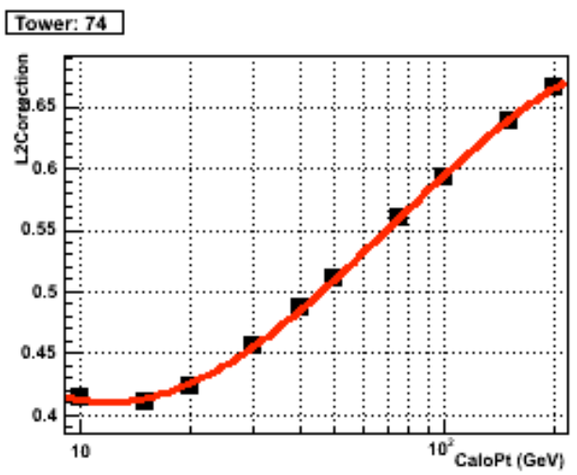




**The fitting function is flexible enough to be used in all η bins although the Barrel scale is considerably smaller than the Endcap and Forward *(backup III)*.**



# Corrections at work

➡ **Application of L2 & L3 corrections as a normal user would do.**

➡ **Corrected Jet Response defined as:**

$$R = \frac{CorJetP_T}{GenJetP_T}$$

**(this is how "response" is realized by users !!!)**

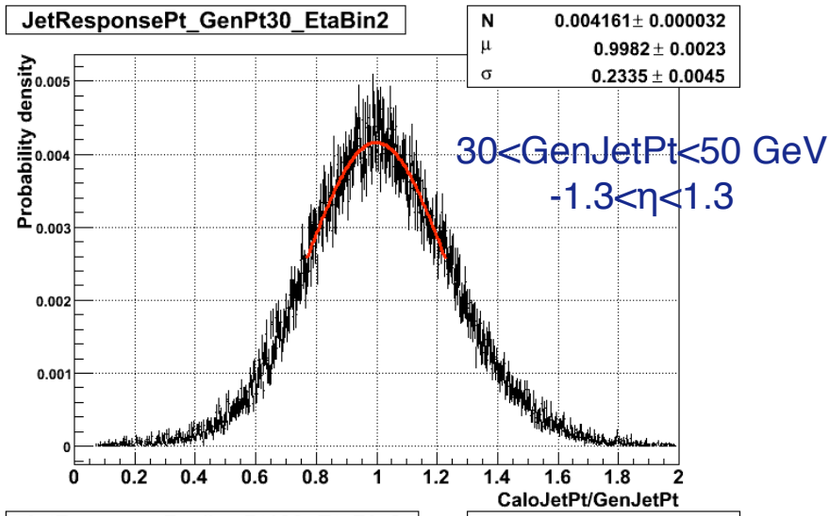
➡ **Binning in terms of GenJetPt because the question answered by the corrections is:** *"how well is a particle level quantity recovered ?"*.

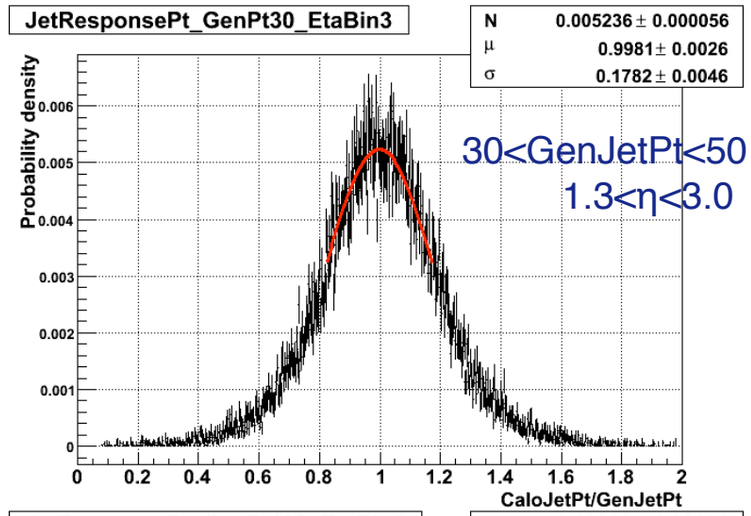
➡ **Consistency check: application of the corrections to exactly the same sample used for their production.**

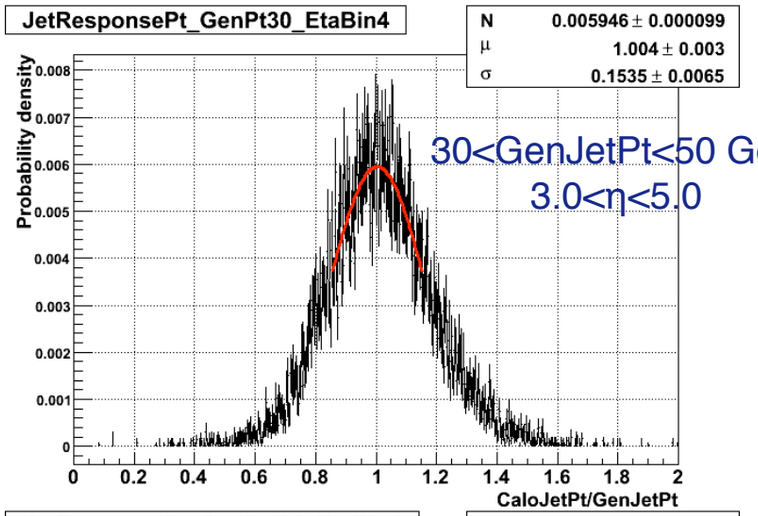
- ✓ **vs Pt: "coarse" η bins, "fine" Pt bins.**
- ✓ **vs η: "fine" η bins, "coarse" Pt bins.**

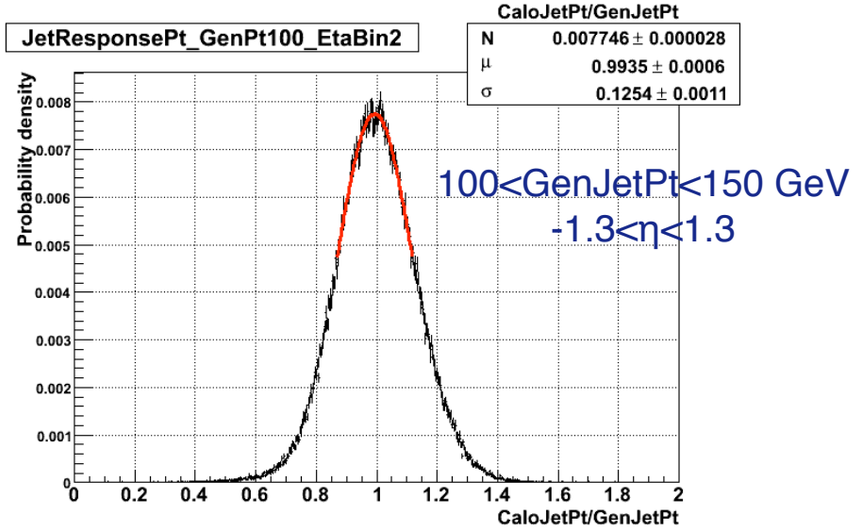
➡ **Application of the corrections to a different spectrum (QCD) and comparison to MCJet corrections.**

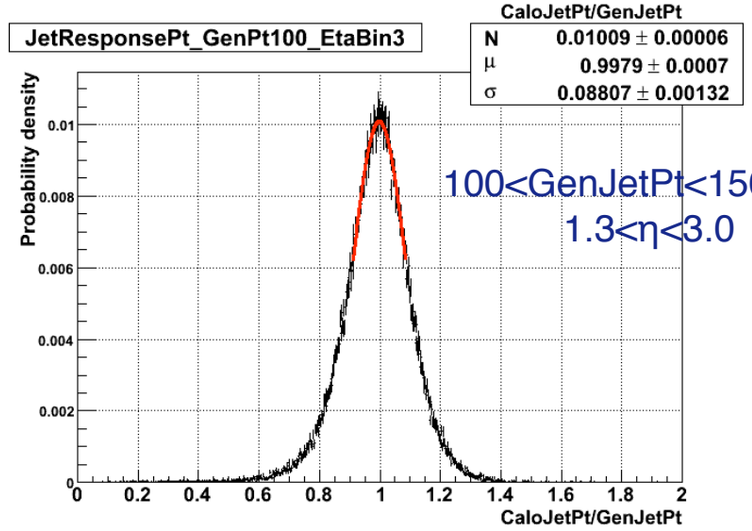
# Corrected Jet Response distributions

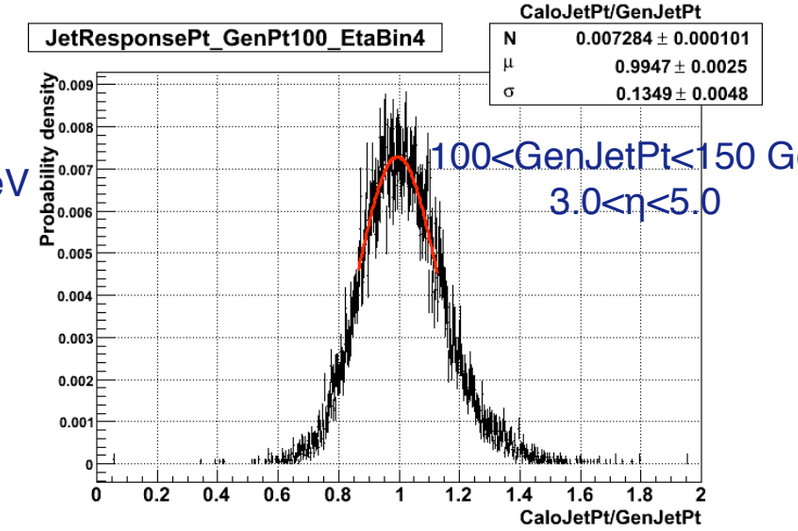


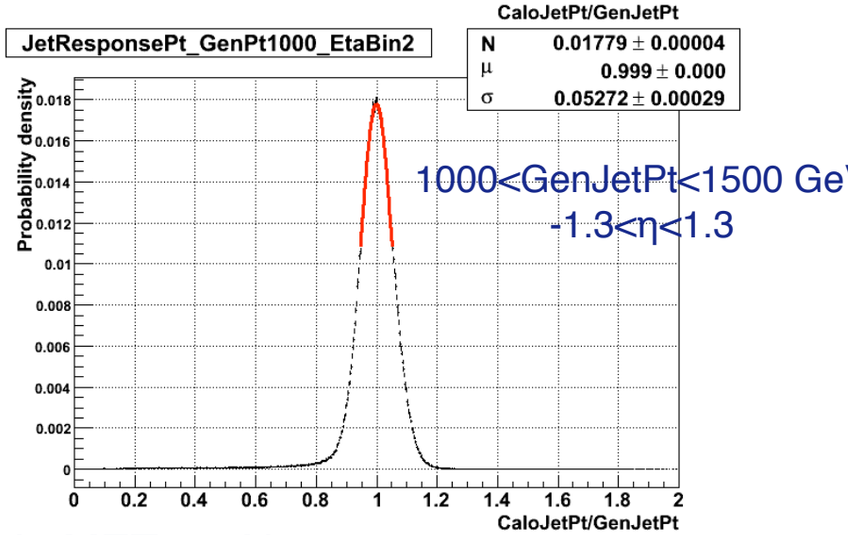



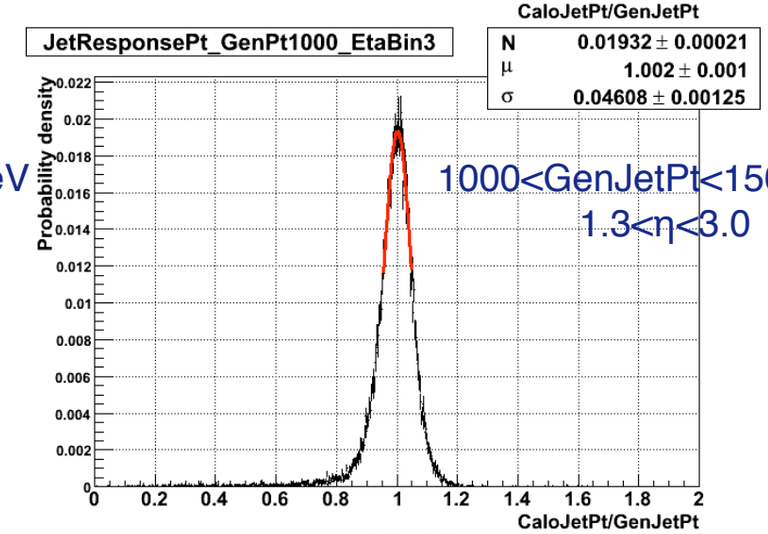



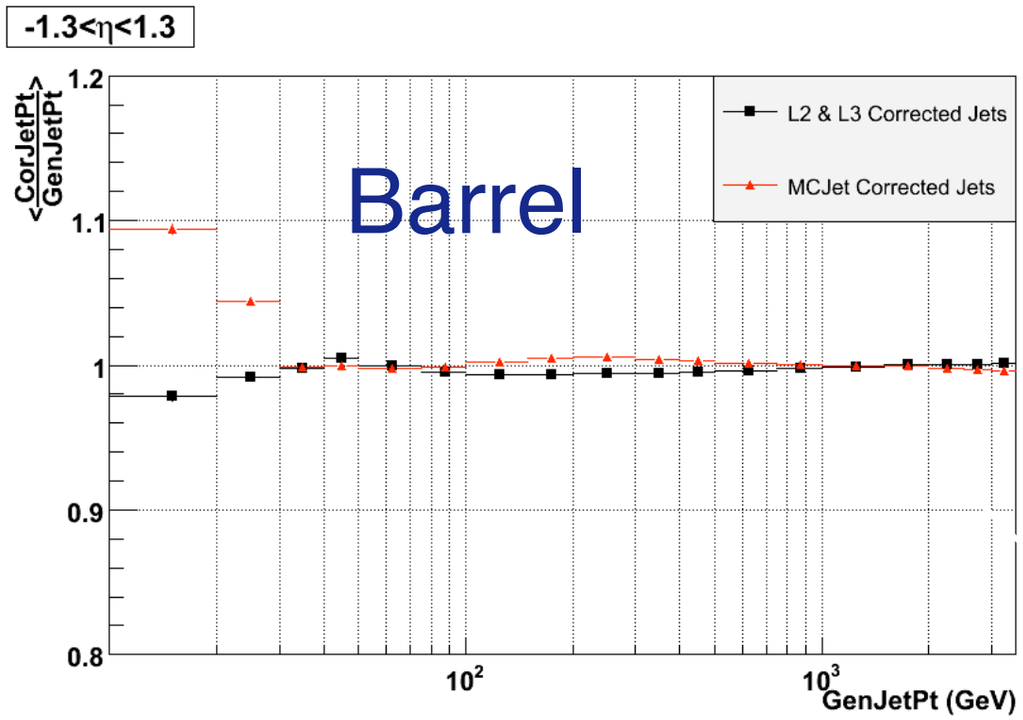



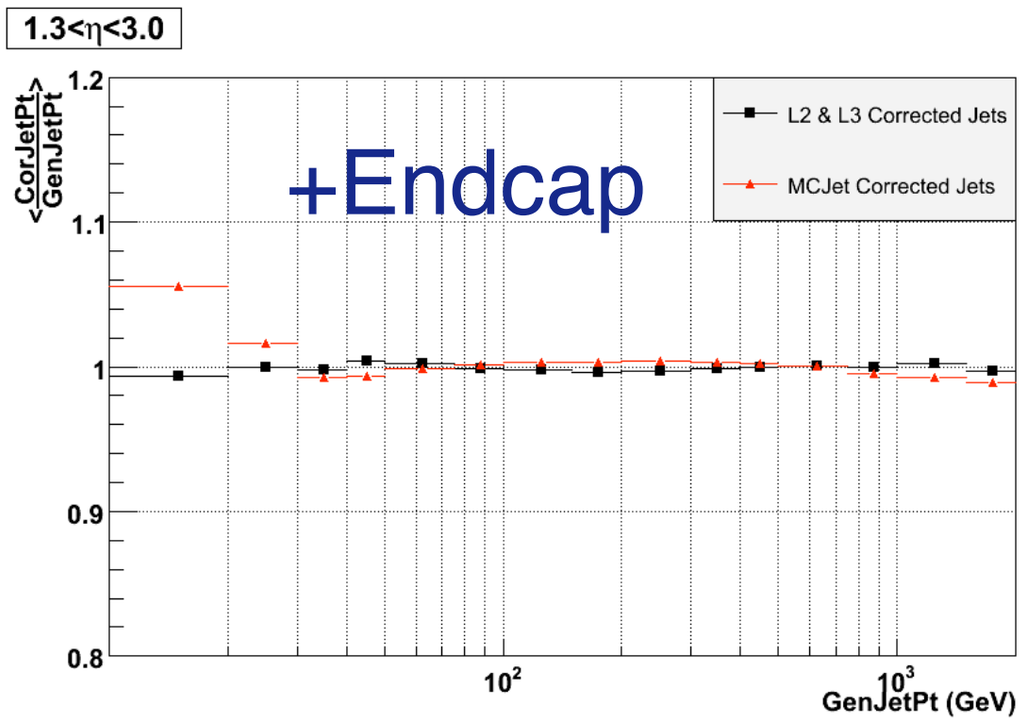



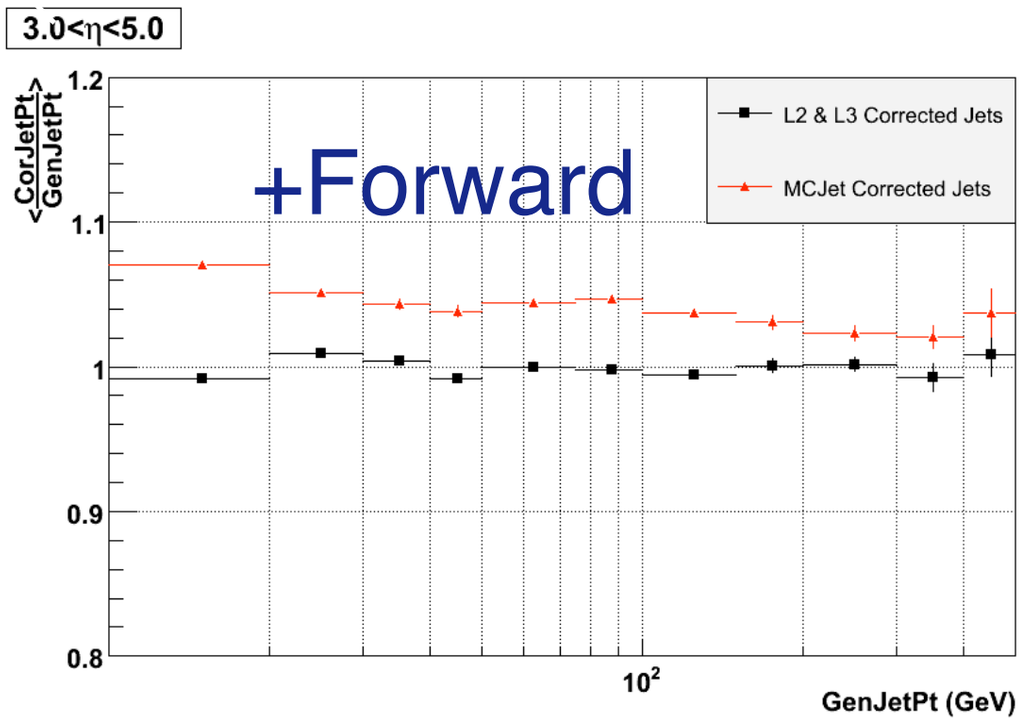




**QCD sample, all Pt_hat bins, leading 2 GenJets.**

# Consistency vs Pt

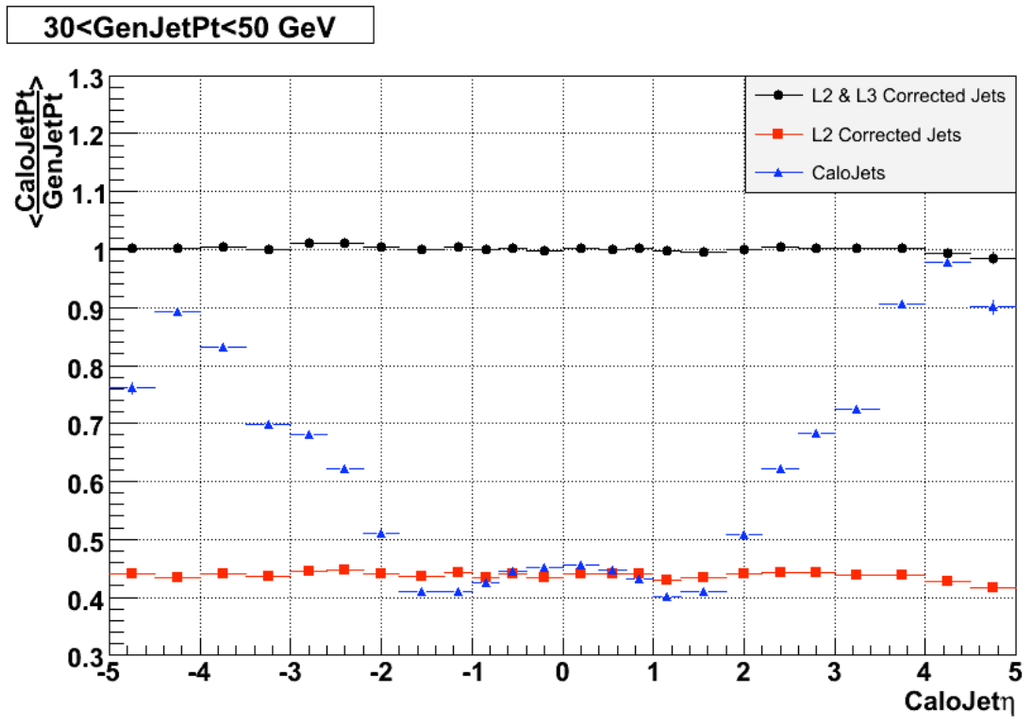


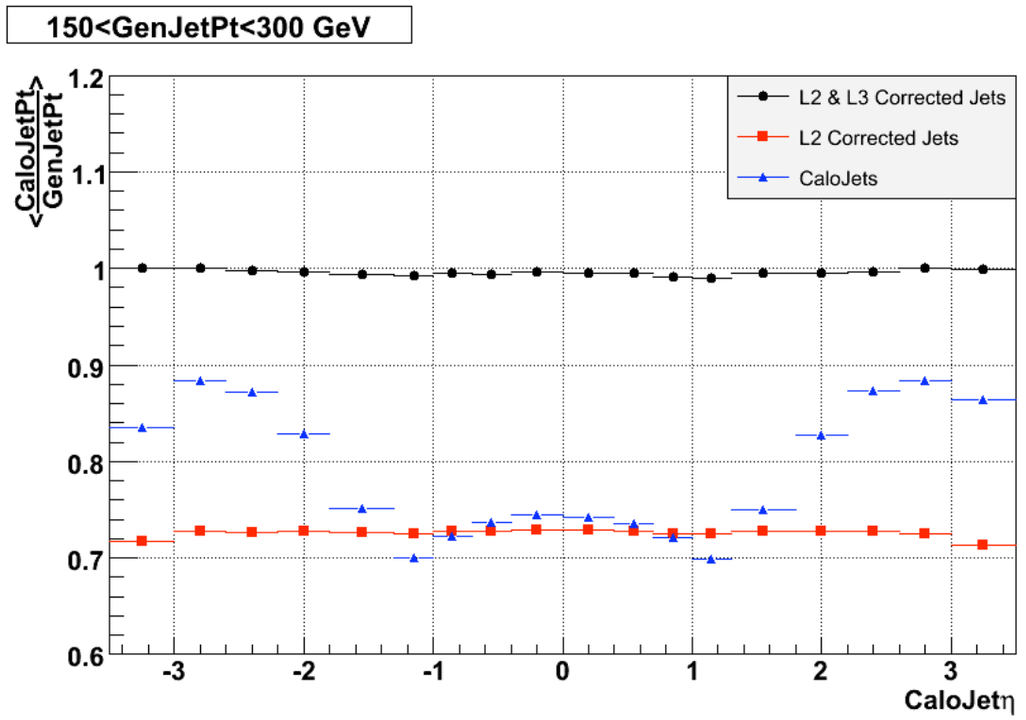



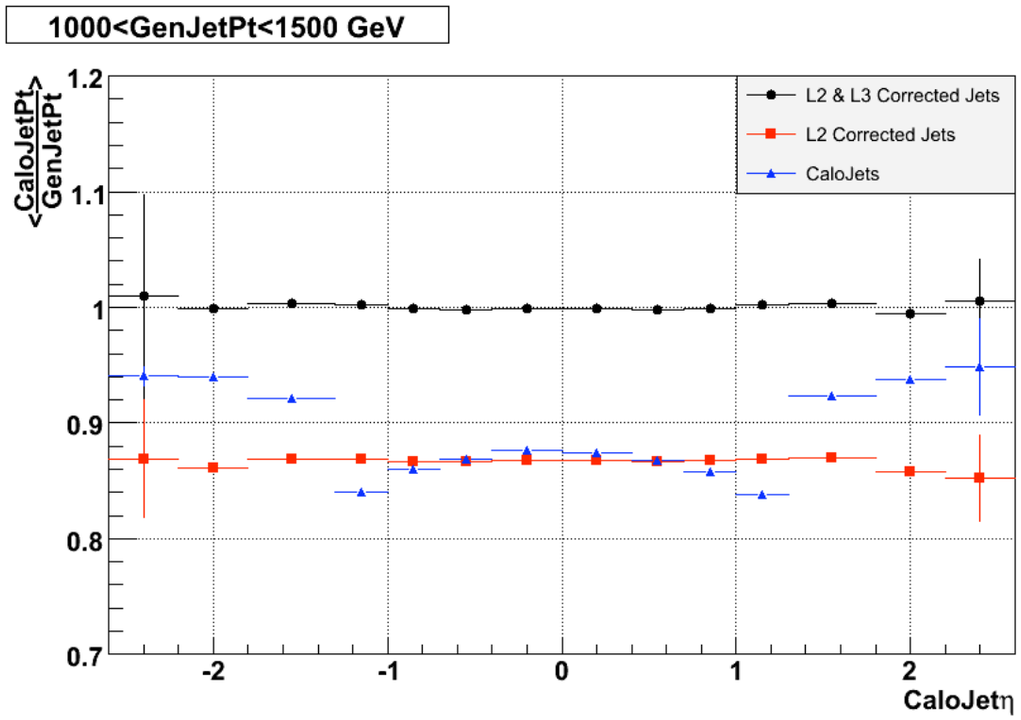

✓ The corrections are consistent within 2% for all Pt's and η regions.
✓ Improvement with respect to MCJet corrections at very low Pt.

# Consistency vs η

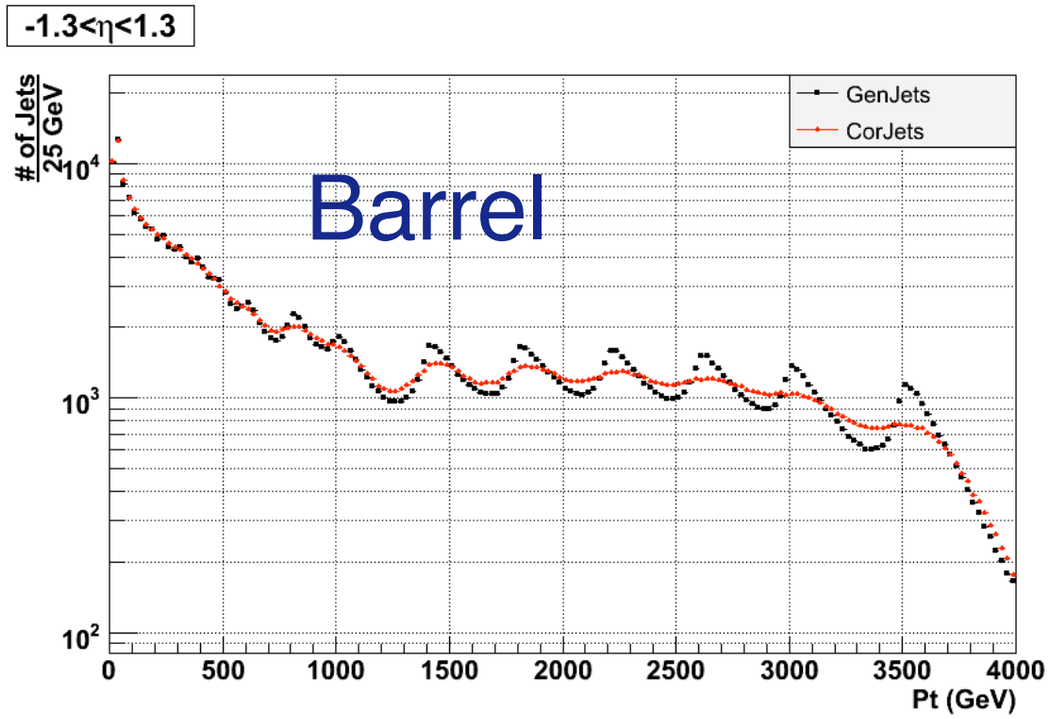



**The corrections are consistent vs η within 2% for all Pt's, both at L2 and L2&L3.**

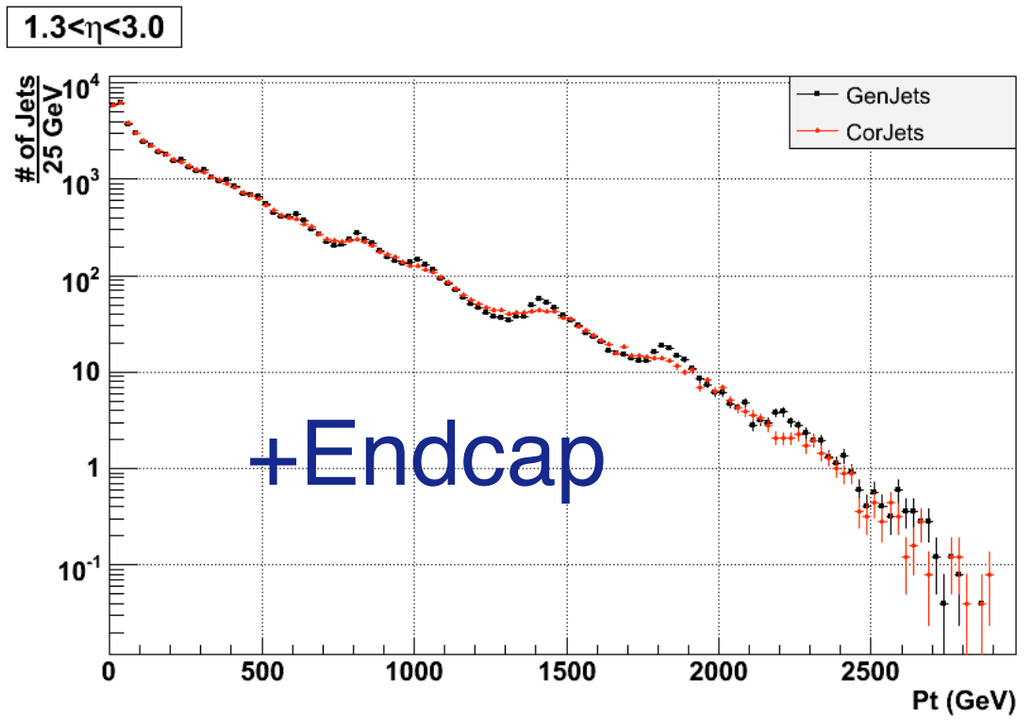


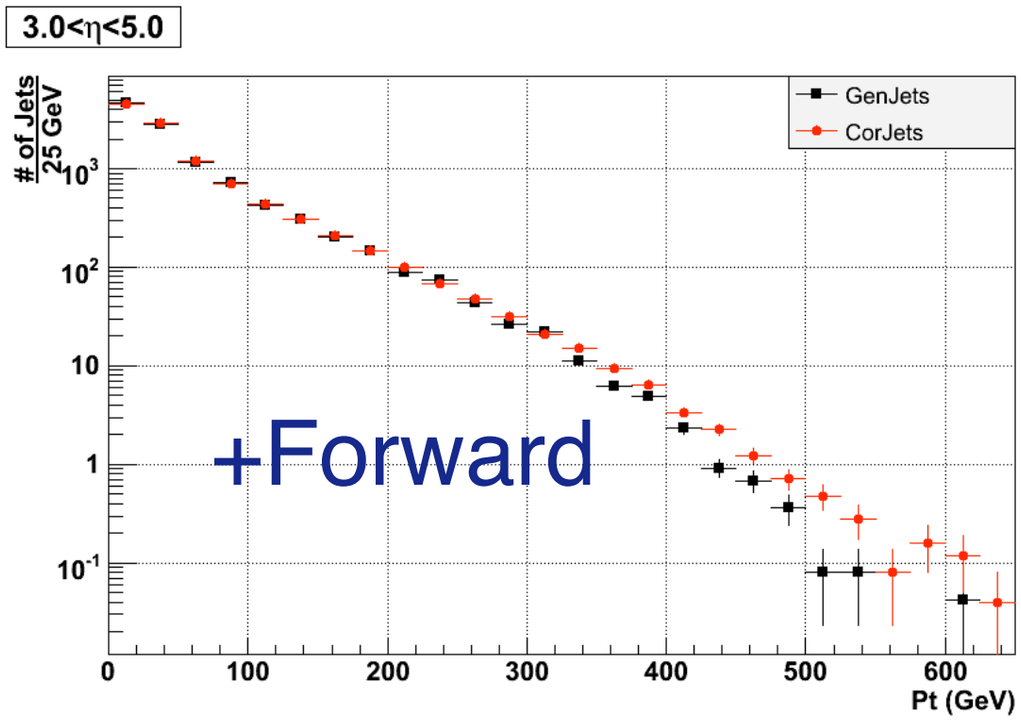



# Spectrum reconstruction




**Resolution smearing is evident !!!**

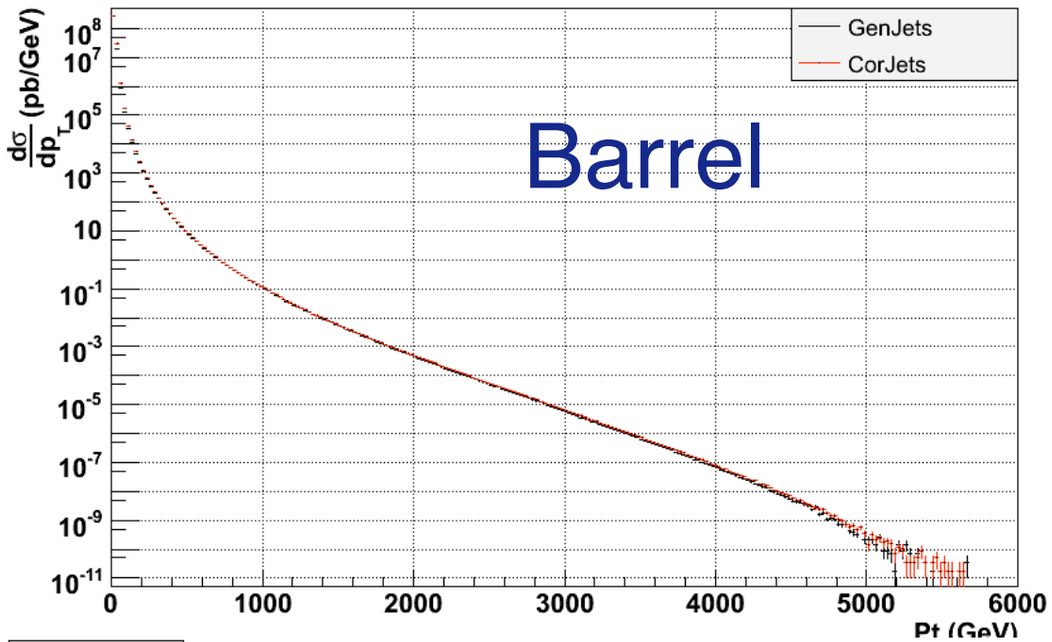


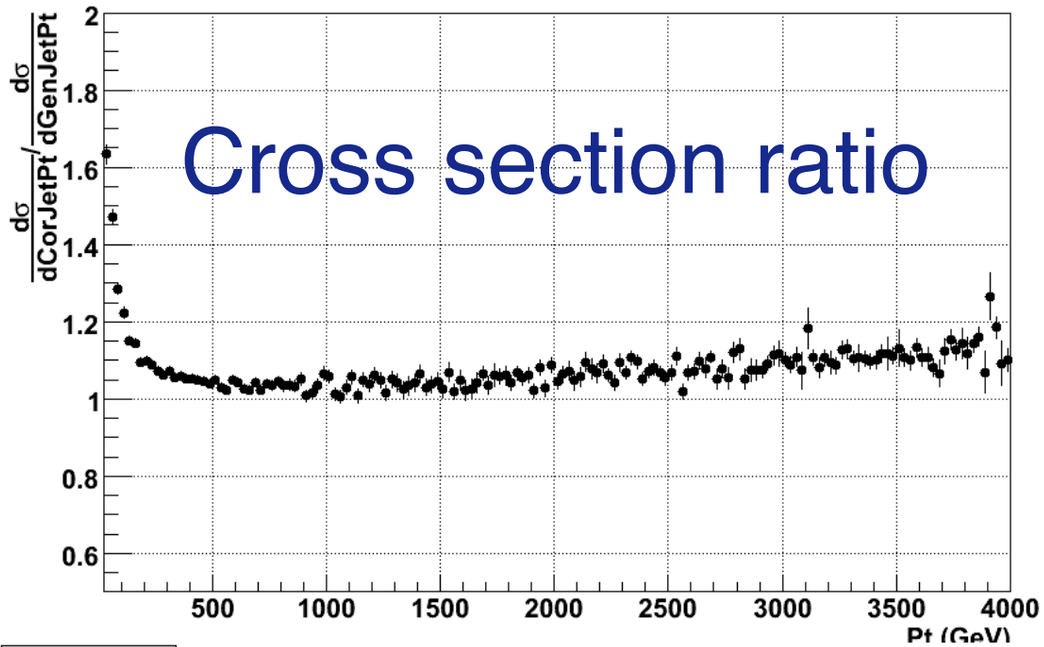
# QCD Spectrum reconstruction

**Cross section ratio is very close to 1 and well behaved.**
**Analysis needs to correct for smearing effects separately: jet energy corrections cannot do it !!**

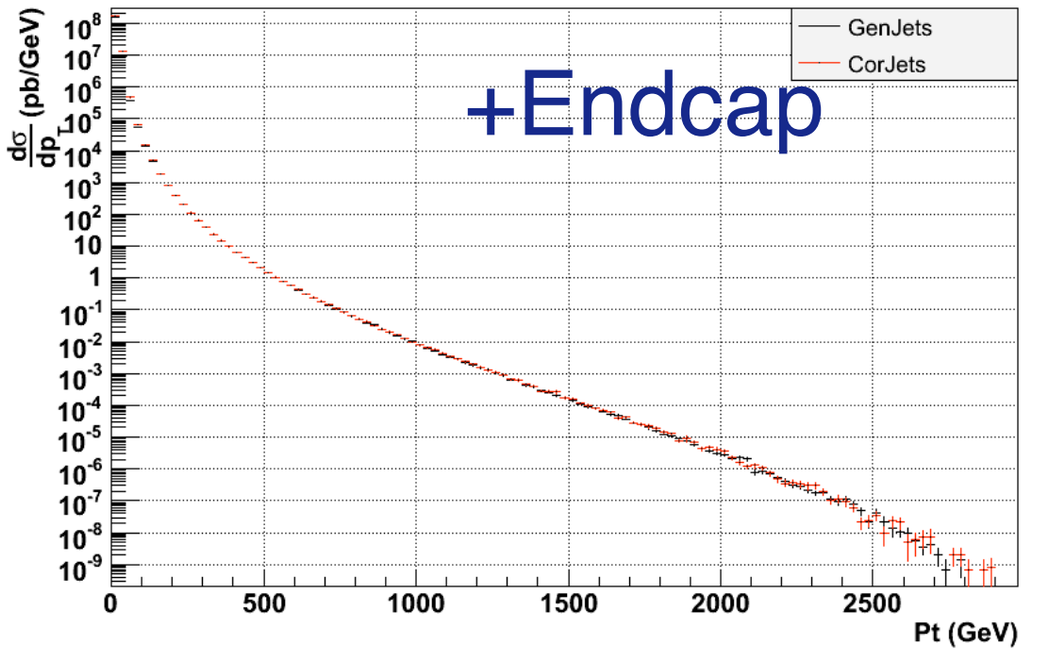
-1.3<η<1.3



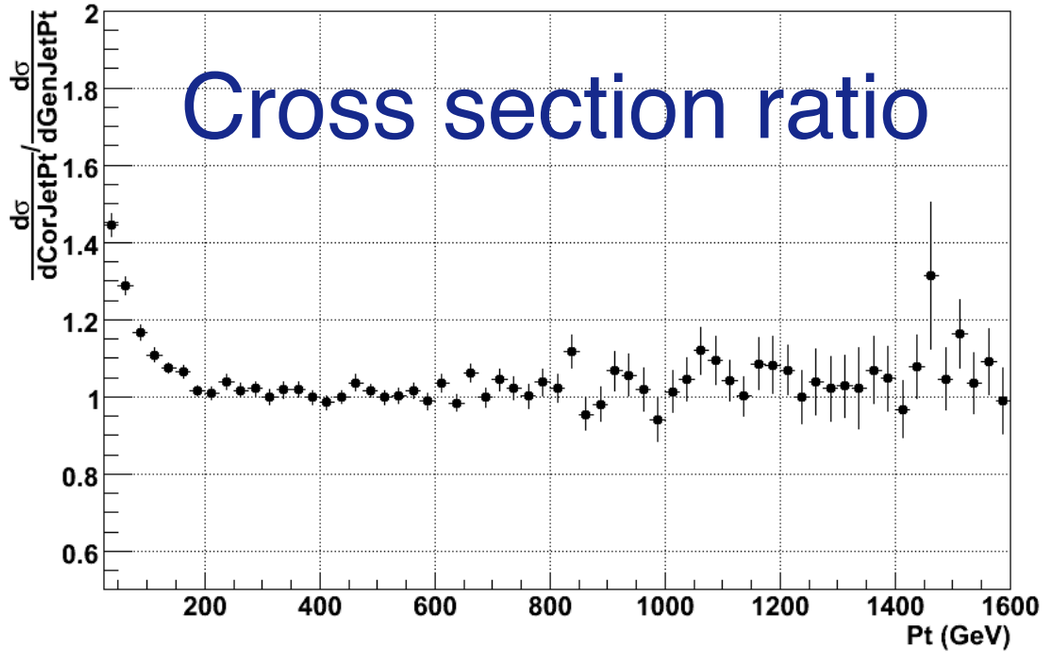

-1.3<η<1.3



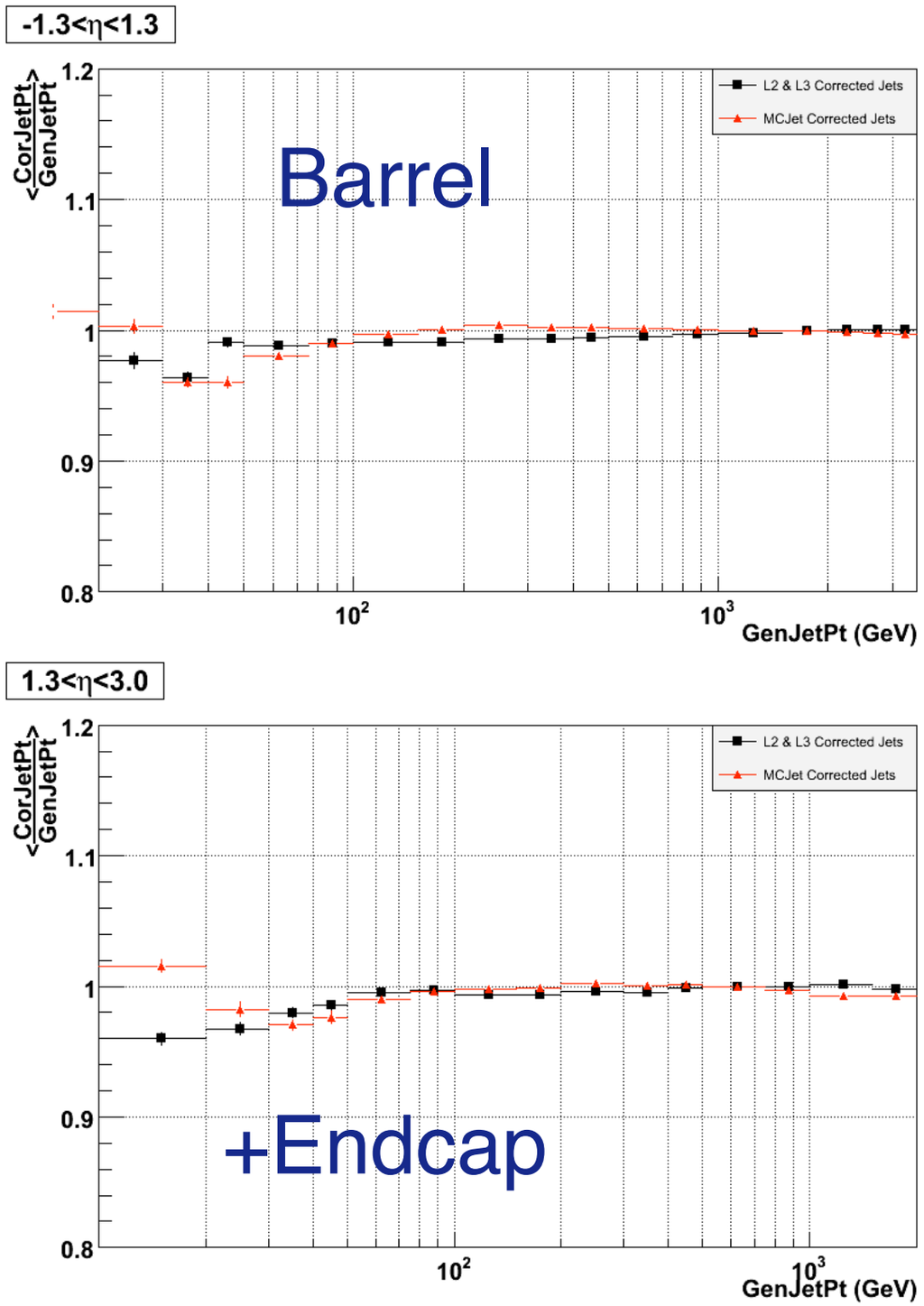

1.3<η<3.0




1.3<η<3.0



# Correcting Jets from the QCD spectrum



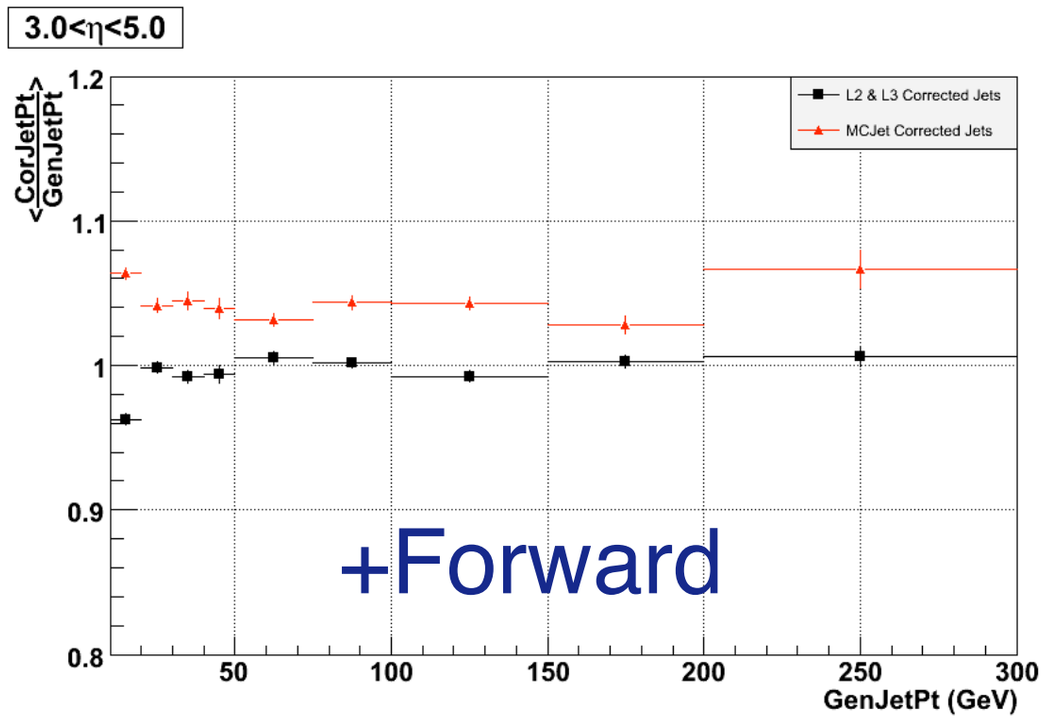




**All Jets, falling QCD spectrum.**

**Although jets come from a very different spectrum than the one used to produce the corrections, they are corrected reasonably well.**

**MCJet corrections overcorrect the +Forward jets by ~5% due to the asymmetry present in CMSSW_1_5_2.**



# L2 & L3 Corrections vs MCJet

## Factorized L2 & L3 corrections

- ✓ GenJetPt binning.
- ✓ Response measure is CaloJetPt-GenJetPt.
- ✓ Only 2 leading GenJets (matched).
- ✓ The correction factor as a function of CaloJetPt is calculated before the application.
- ✓ 82 η bins.
- ✓ No +/- η symmetry assumed.
- ✓ Continuous η bins.

## MCJet corrections

- ✓ GenJetEt binning.
- ✓ Response measure is CaloJetEt/GenJetEt.
- ✓ All GenJets (matched).
- ✓ The correction factor as a function of CaloJetEt is calculated on the fly.
- ✓ 16 |η| bins.
- ✓ +/- η symmetry assumed.
- ✓ Discontinuous in η.

# Applying the L2 & L3 corrections

```
es_source L2JetCorrectorIcone5 = L2RelativeCorrectionService {
                string tagName = 'CMSSW_152_L2Relative_iterativeCone5'
                string label = 'L2RelativeJetCorrectorIcone5'
}
es_source L3JetCorrectorIcone5 = L3AbsoluteCorrectionService {
                string tagName = 'CMSSW_152_L3Absolute_iterativeCone5'
                string label = 'L3AbsoluteJetCorrectorIcone5'
}
module L2JetCorJetIcone5 = JetCorrectionProducer {
                InputTag src = iterativeCone5CaloJets
                vstring correctors = {"L2RelativeJetCorrectorIcone5"}
                untracked string alias = "L2JetCorJetIcone5"
}
module L3JetCorJetIcone5 = JetCorrectionProducer {
                InputTag src = L2JetCorJetIcone5
                vstring correctors = {"L3AbsoluteJetCorrectorIcone5"}
                untracked string alias = "L3JetCorJetIcone5"
}
module plots = JetPlotsExample {
                string CaloJetAlgorithm = "L3JetCorJetIcone5"
                string GenJetAlgorithm = "iterativeCone5GenJets"
}
path p = {L2JetCorJetIcone5,L3JetCorJetIcone5,plots}
```

**The factorized L2,L3 correction modules are technically independent of each other but they form a complete correction only if they are applied sequentially (the input for the L3 correction is the output of the L2).**

CaloJet → L2RelativeCorrectionService → L2JetCorJet → L3AbsoluteCorrectionService → L3JetCorJet

# Example

- scramv1 project CMSSW CMSSW_1_6_7
- cd CMSSW_1_6_7/src
- cmscvsroot CMSSW
- cvs co -r jet_corrections_16X_L2L3 JetMETCorrections/MCJet
- cvs co -r jet_corrections_16X_L2L3 JetMETCorrections/Modules
- cvs co -r jet_corrections_16X_L2L3 CondFormats/JetMETObjects
- cvs co -r jet_corrections_16X_L2L3 RecoJets/JetAnalyzers
- scramv1 b
- eval `scramv1 runtime -csh`
- cd RecoJets/JetAnalyzers/test
- cmsRun L2L3CorJetsExample.cfg

# Conclusions

☑ The factorized L2&L3 corrections for CMSSW_1_5_2 are available for all officially supported jet algorithms and **are ready for release upon approval**.

☑ The consistency tests prove that uniformity in η is achieved and the corrections are good within 2% for the whole Pt range.

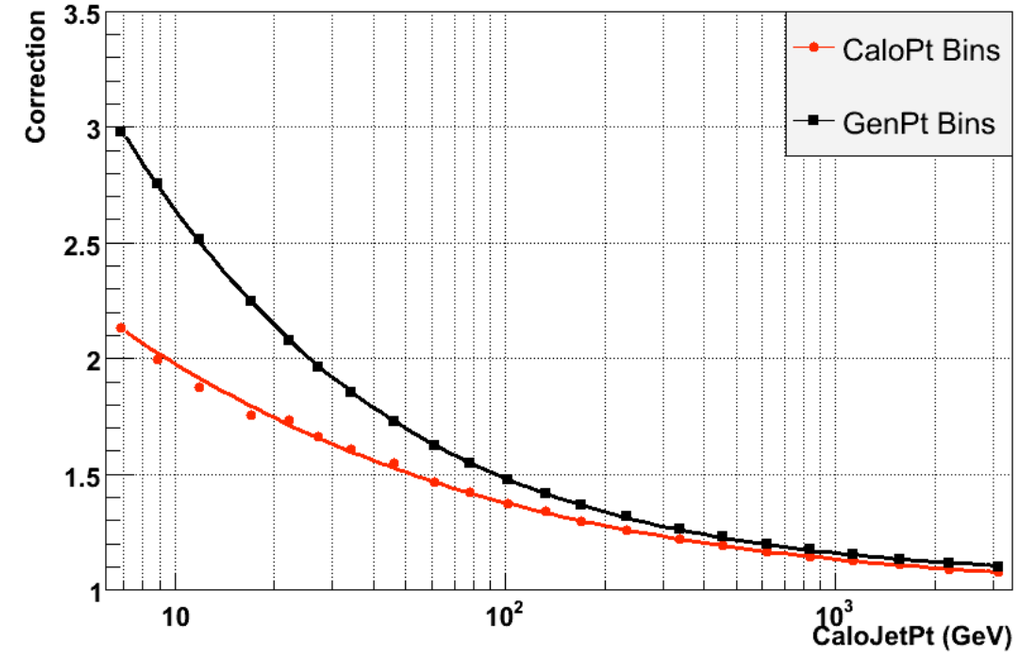
☑ The factorized L2&L3 corrections work at least as good as MCJet corrections.

☑ Next (short term) step: replacement of the L2 correction by data driven method (Dijet Balance).

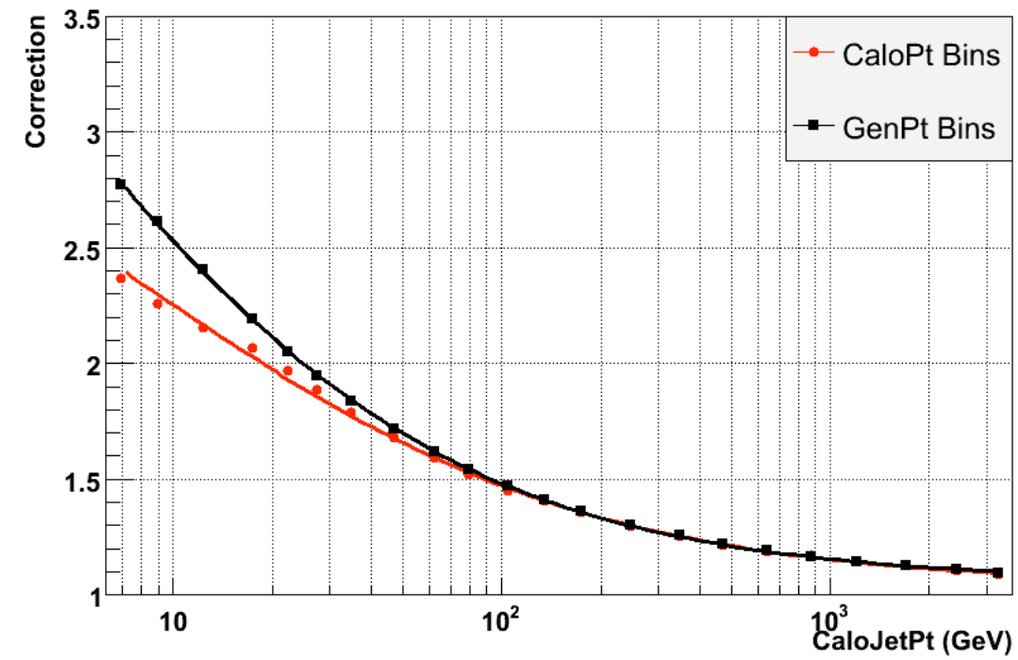
☑ Thanks: to **Fedor Ratnikov** for helping integrate the code in CMSSW and to **Anwar Bhatti** for the fruitful discussions.

# Backup I
## binning in CaloJetPt vs binning in GenJetPt

**QCD Spectrum**



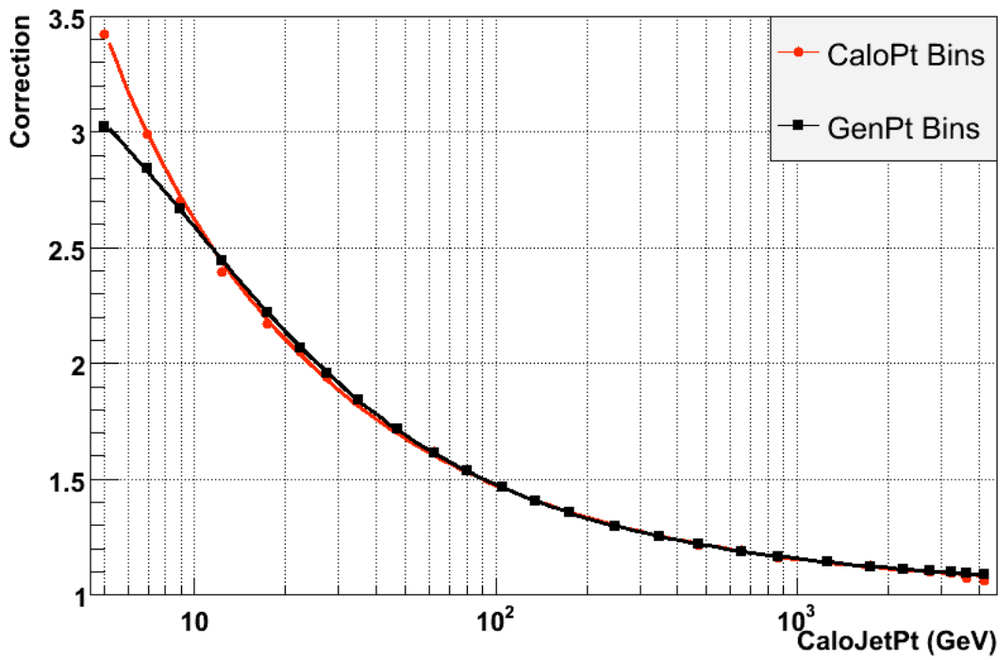

**Flat Spectrum (all jets)**




✓ **The derivation of L3 correction by binning in CaloJetPt is heavily spectrum dependent.**
✓ **For a flat spectrum, the two approaches yield the same correction.**
✓ **The advantages of using the GenJetPt binning method are the spectrum insensitivity (allowing us to provide a generic correction for all users) and the resemblance to the data driven method for determining the absolute Pt scale (binning in γ/Z Pt).**

$$C(< CaloJetP_T >) = \frac{< CaloJetP_T > - << \Delta P_T >>}{< CaloJetP_T >}$$

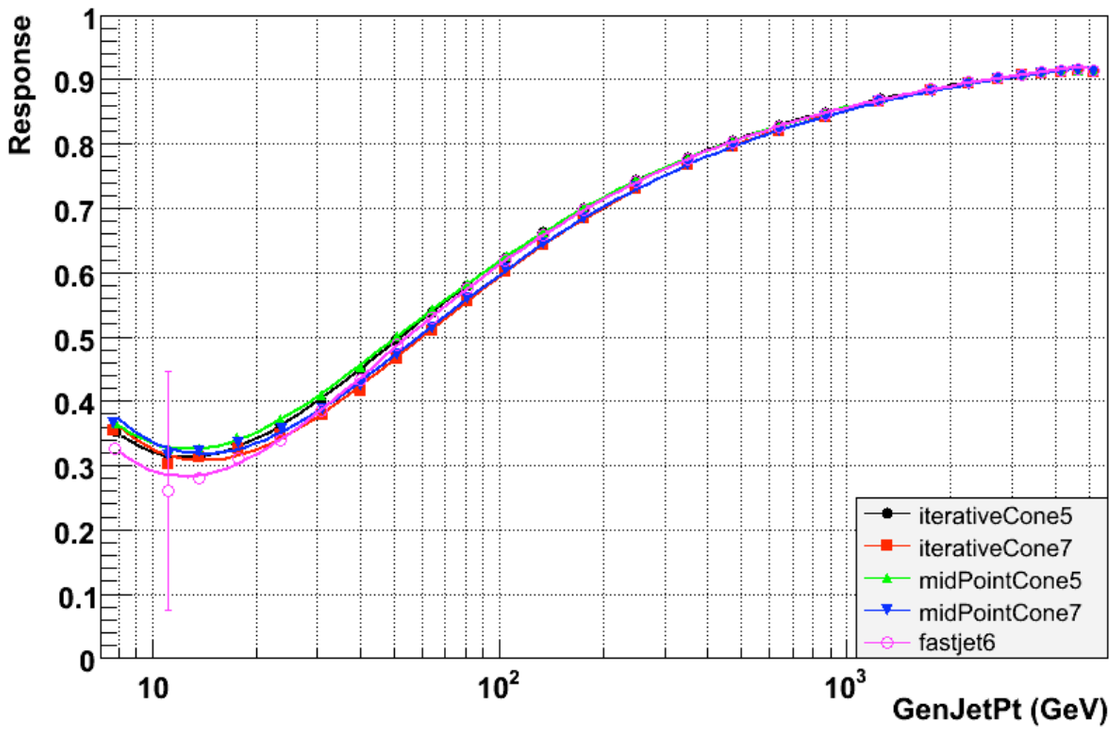
**Flat Spectrum (2 leading GenJets)**



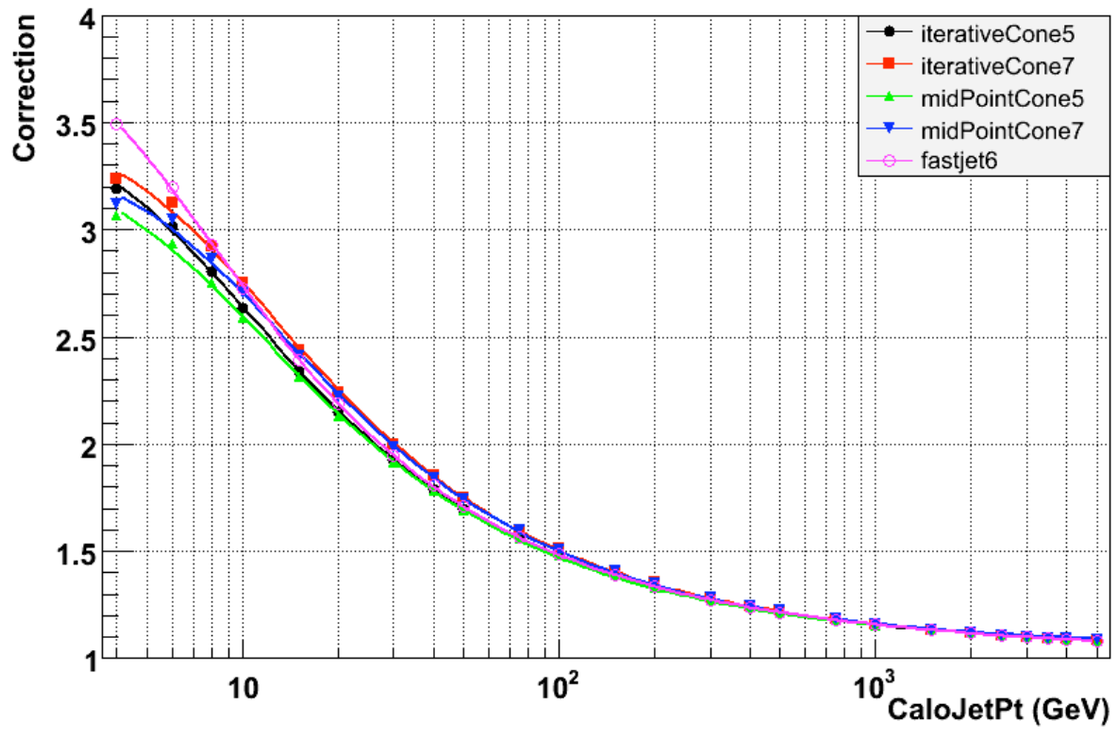
# Backup II

## Response and L3Correction for different Jet Algorithms

**Response, |η|<1.3**



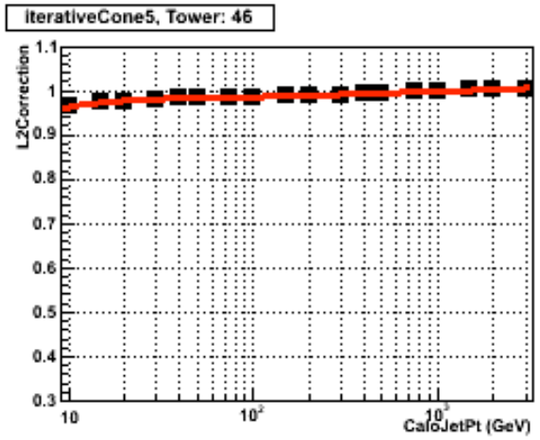

**L3Correction**

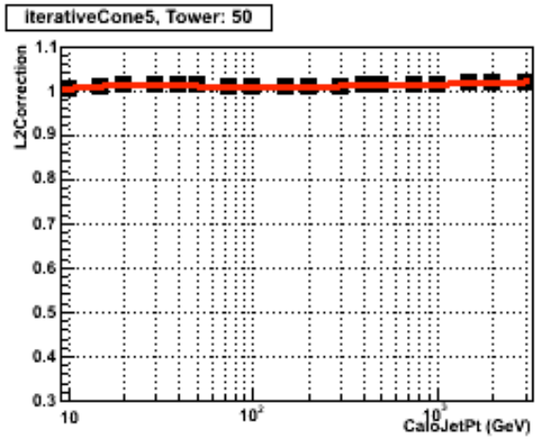


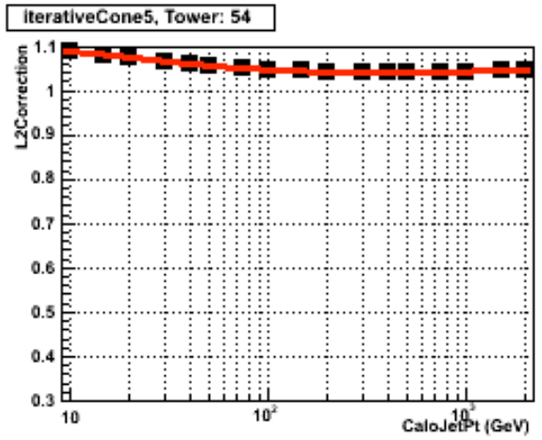

**L3 Correction does not change significantly for different Jet algorithms. Considerable variations are present only at low Pt's.**

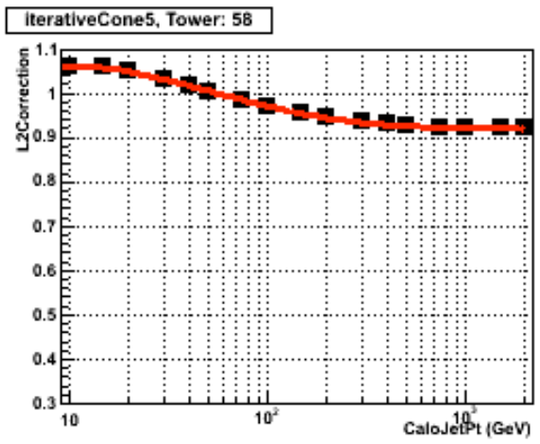
# Backup III

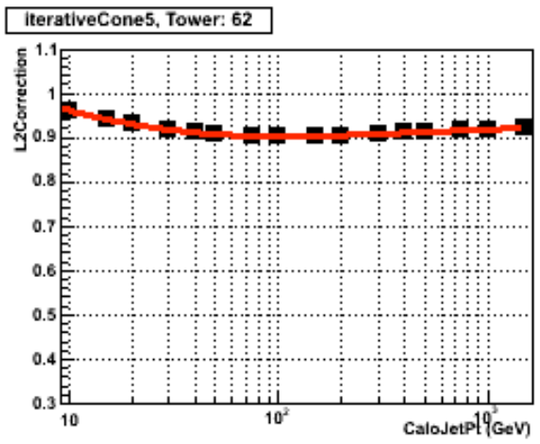
## L2Correction (same scale)

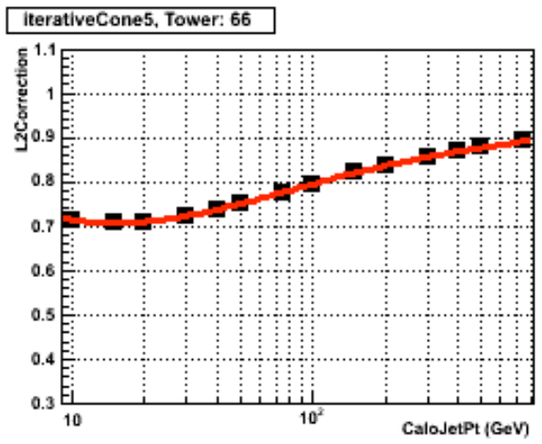


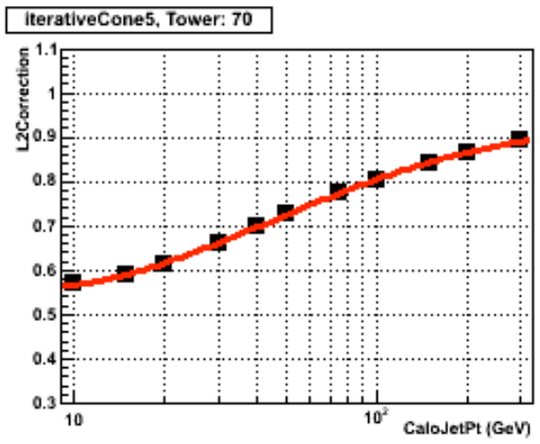



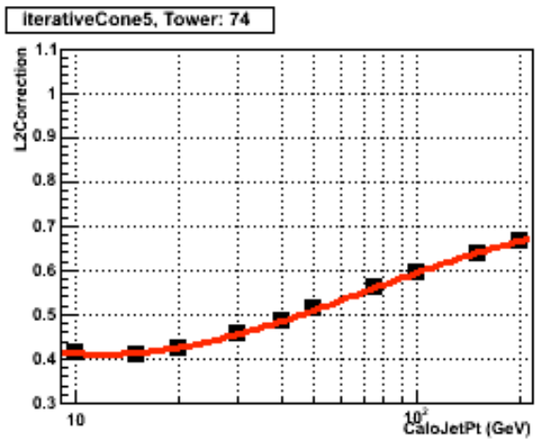



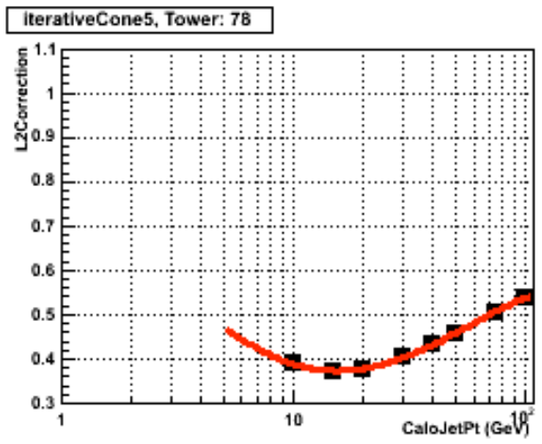



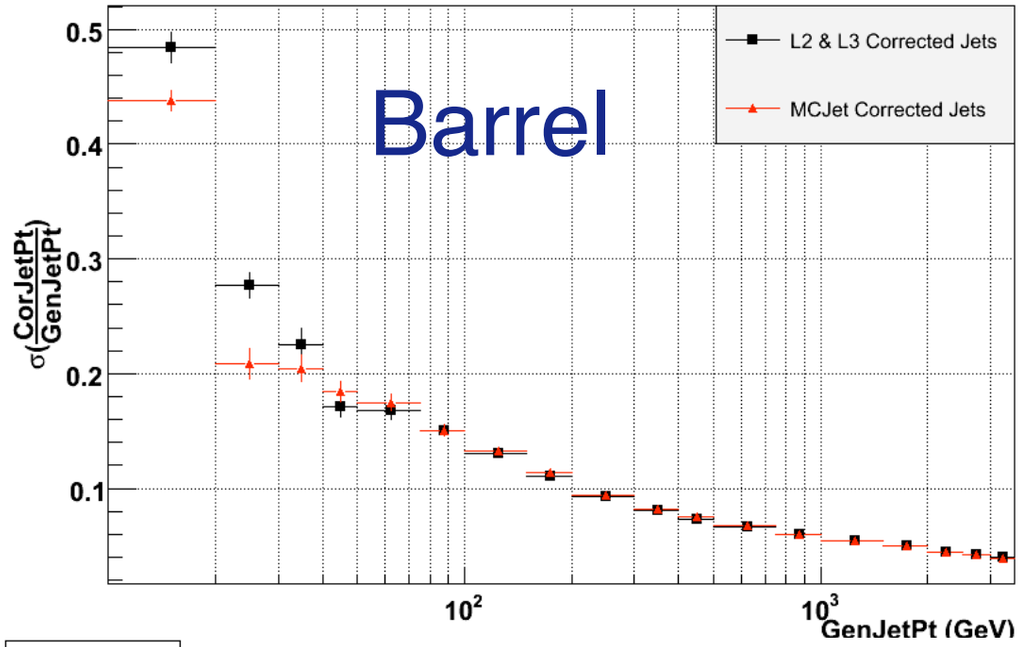



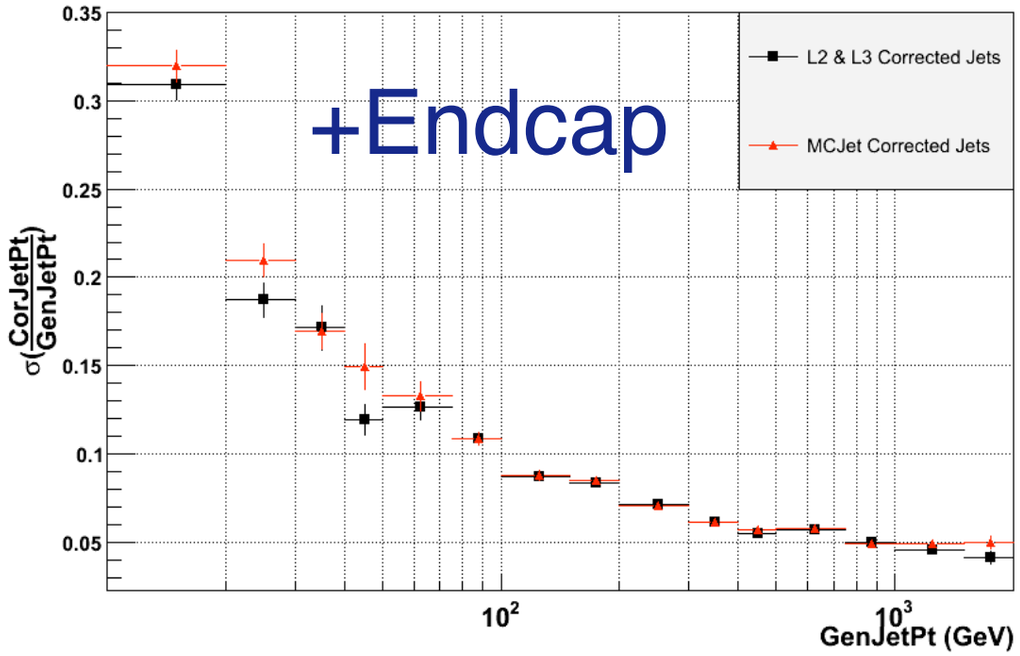
# Backup IV
## Correcting Jets from the QCD spectrum (Resolution)

-1.3<η<1.3

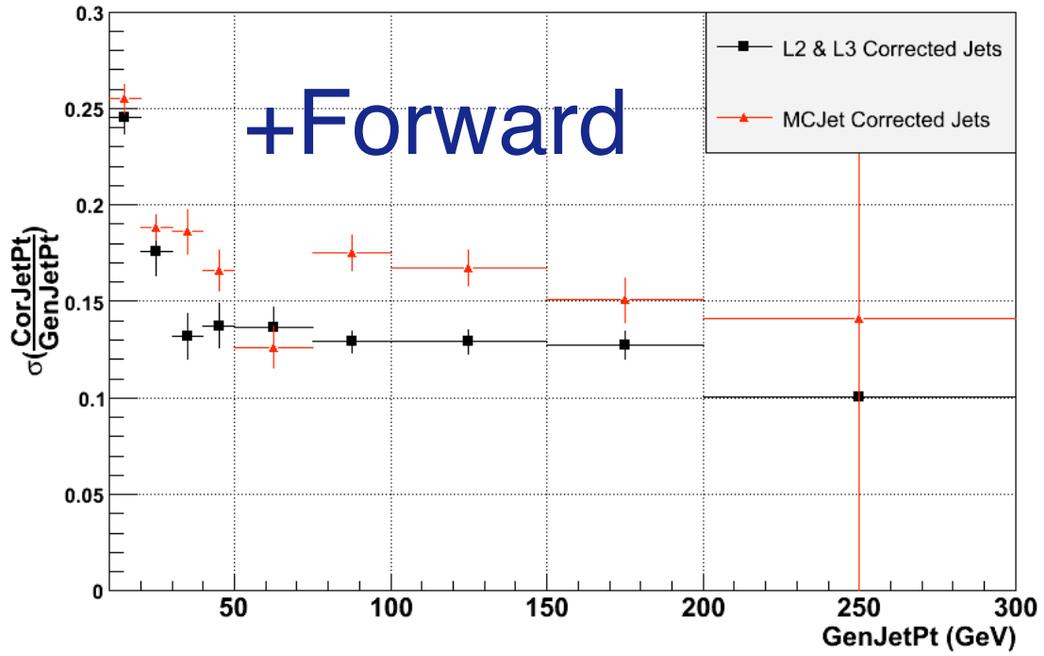



**All Jets, falling QCD spectrum.**

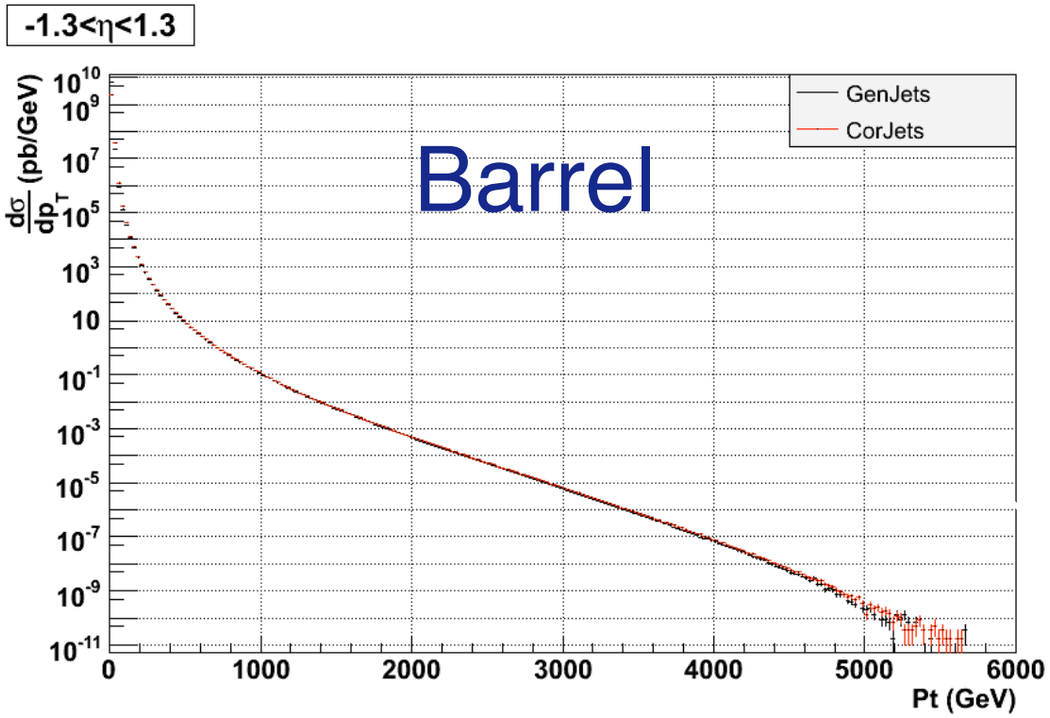
1.3<η<3.0

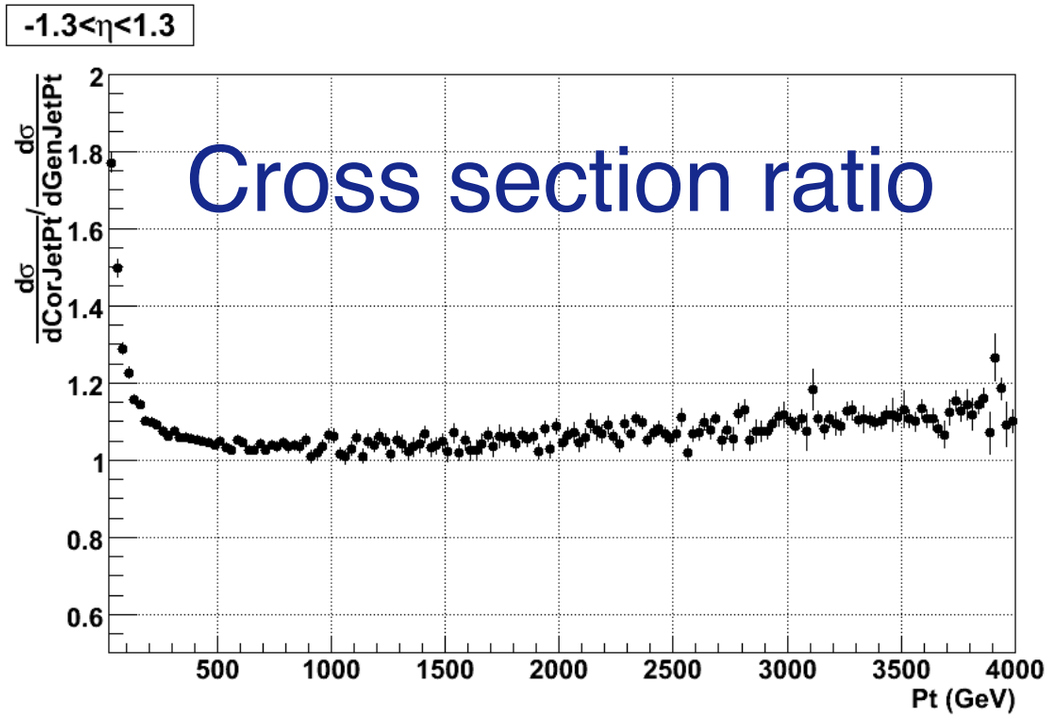


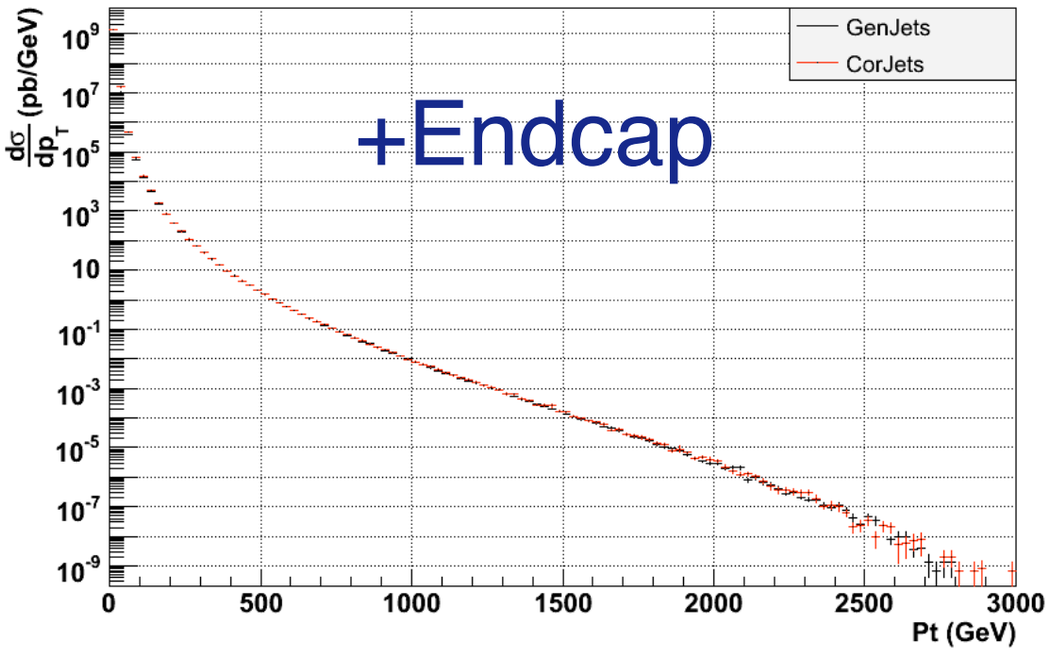

3.0<η<5.0

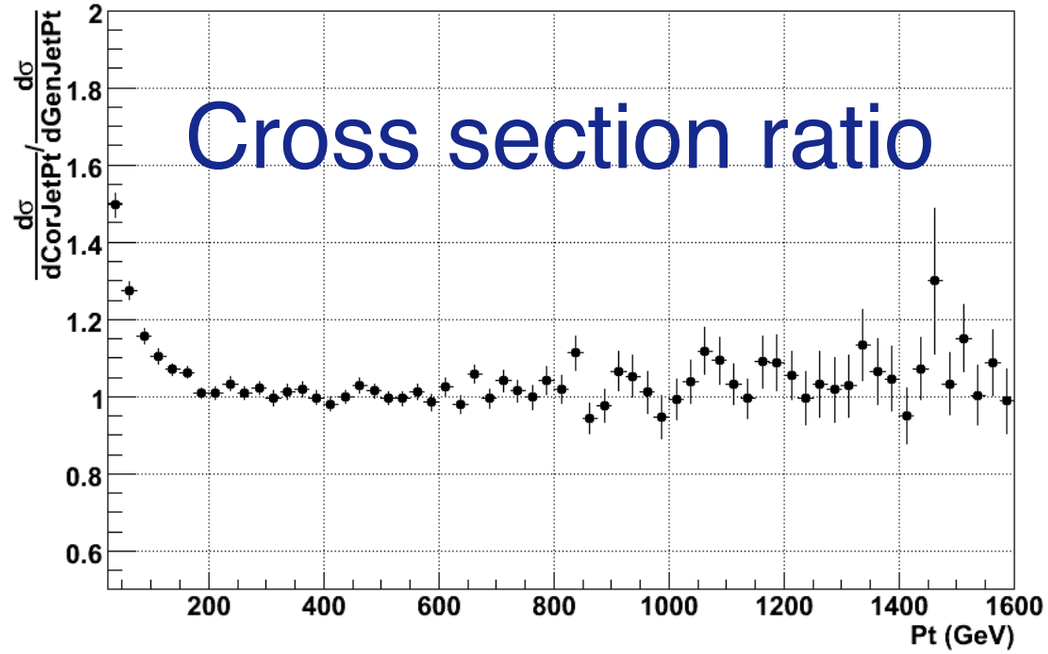


# Backup V
## Inclusive QCD Spectrum



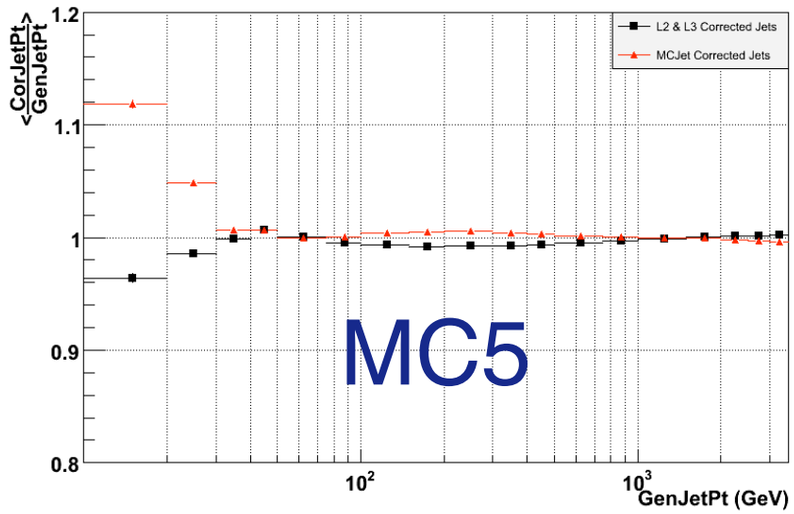



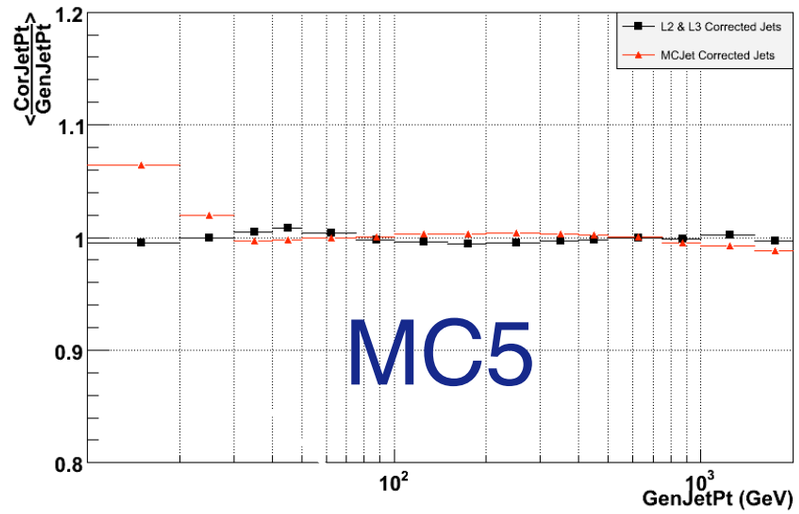



# Backup VI
## Consistency for other jet algorithms

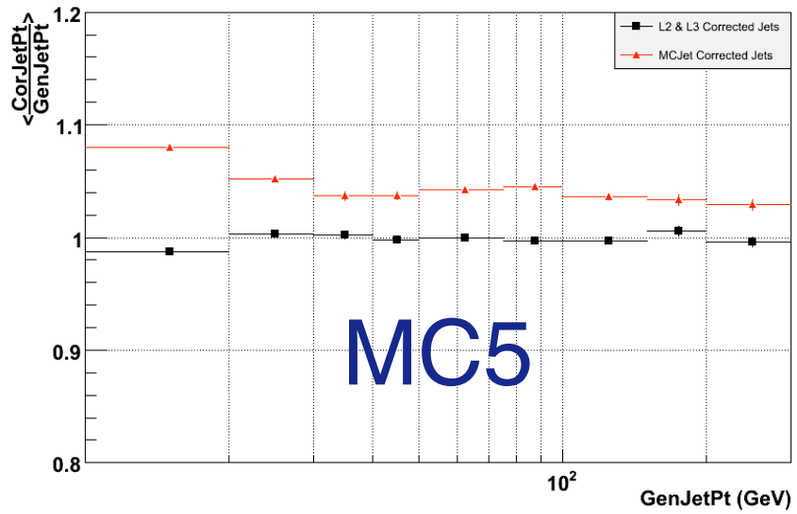
midPointCone5, -1.3<η<1.3



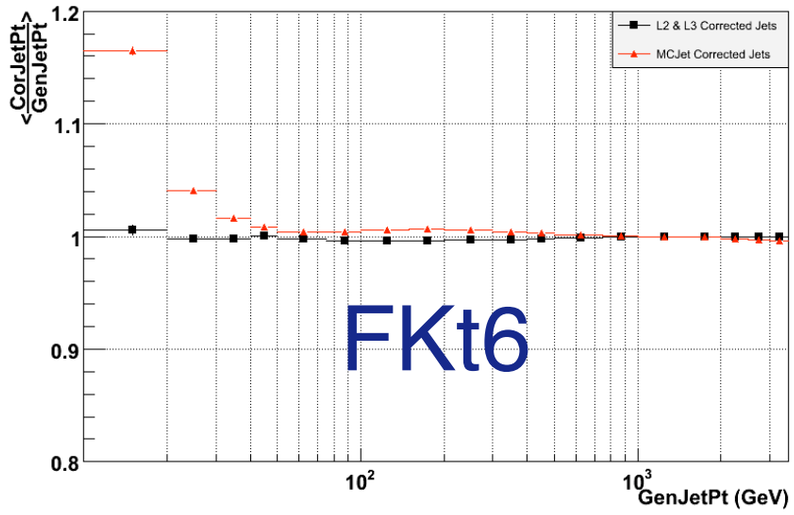

midPointCone5, 1.3<η<3.0



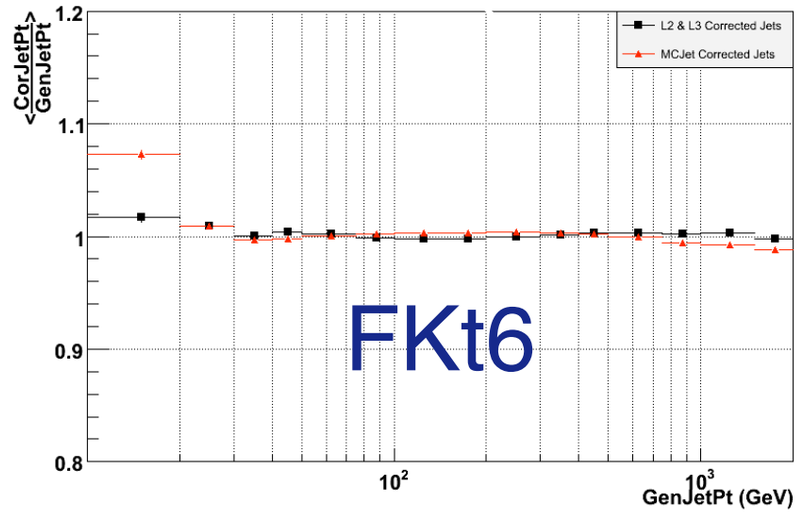

midPointCone5, 3.0<η<5.0



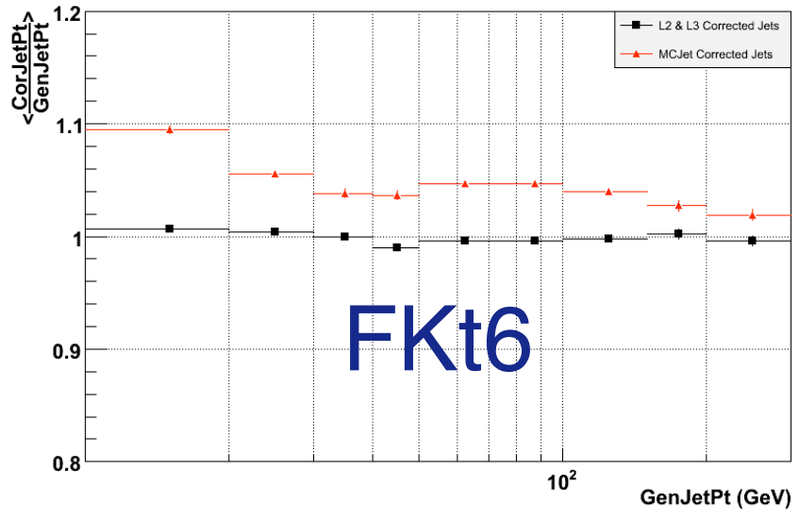

fastjet6, -1.3<η<1.3




fastjet6, 1.3<η<3.0




fastjet6, 3.0<η<5.0




Barrel +Endcap +Forward